METALLURGIA

The British Journal of Metals

(INCORPORATING THE METALLURGICAL ENGINEER.)

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METALLURGIA

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INCORPORATING "THE METALLURGICAL ENGINEER".

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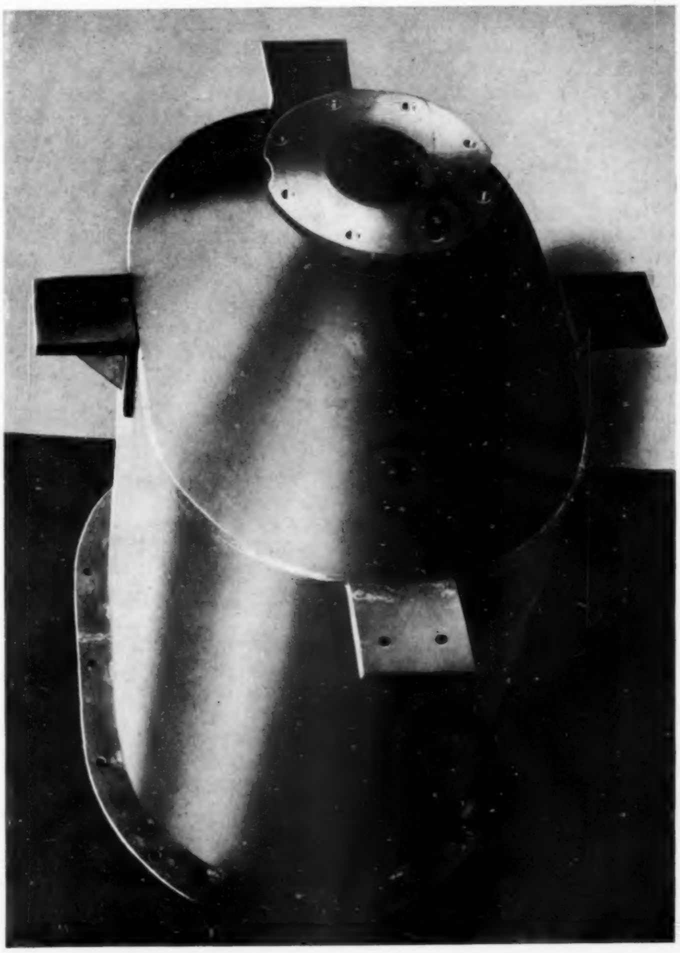
Nickel-clad Steel Plate

Its Manufacture and Fabrication

In the form of sheet and strip, nickel-coated steel has been on the market some time, but production has only been perfected during recent years. Its availability is now providing a solution to many of those problems where strength and corrosion resistance are required at moderate initial cost. This composite material is discussed briefly and some applications cited.



Nickel-clad steel vessel used in plastic manufacture.

NICKEL-CLAD steel plates consist of mild steel protected on one side by a covering of malleable nickel. This covering, which has all the corrosion-resisting and other properties of ordinary commercial hot-rolled nickel sheet, is firmly bonded to the steel, and the mechanical properties of the composite plate are such that it can be treated as a solid steel plate, practically any form being obtainable from it. For heavy plant, where a separate lining of nickel is at present employed, the use of the solid material presents obvious advantages, particularly where heat transfer is of some importance. Pure nickel and mild steel have practically the same coefficients of expansion, an important advantage during manufacture, whilst in service, when changes in temperature are involved, no strains are set up.

It is well known that for the majority of applications of pure nickel relatively light-section metal is used, the high initial cost of nickel somewhat limiting its application for heavy plant. This difficulty has been overcome by the development of nickel-clad steel, and designers of heavy plant for many processing industries have at their disposal a material having the corrosion-resisting properties of nickel at a moderate initial cost.

The most important factor in the manufacture of nickel-clad steel plates is the production of a true bond between the surfaces in contact. Fortunately, nickel and iron are mutually soluble in all proportions, and if the surfaces in contact are kept clean during the heating process it is possible to obtain a good bond simply by hot-rolling. This having been obtained, the working properties of nickel and mild steel are sufficiently alike to permit the rolling of the composite slab to whatever thickness is desired.

Since nickel-clad steel sheets and strip are made throughout by hot rolling, the normal finish is that of hot-rolled steel and hot-rolled nickel. The nickel is covered by a thin tightly adherent, and glossy oxide film, dark olive brown in colour, which has very good corrosion-resisting properties; in fact, the corrosion resistance of the hot-rolled nickel surface is quite as good as that of cold-rolled nickel, and for the heavy type of plant, for which nickel-clad steel is recommended, this surface is quite suitable.

Making Nickel-clad Steel Plates

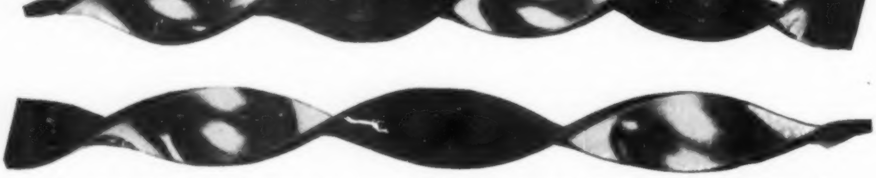
Careful attention to detail is required from start to finish in the process of manufacture, particularly in the heating-up process prior to hot-rolling. In the first place, steel and nickel slabs, of thicknesses calculated to give the required ratio in the finished plate, are specially prepared and fixed together so that no separation can occur during rolling. After bringing the composite pack up to the high temperature necessary for rolling, it is quickly transferred to the rolls and reduced to the required thickness.

At the temperature of rolling the nickel and steel surfaces weld together under the pressure of the rolls and form a strong intermetallic bond, so that no separation of the nickel from the steel can subsequently occur, whatever the treatment to which it is subjected.

Nickel-clad steel plates are available in a variety of sizes. It has been found, however, that ¼-in. thick plate, having a layer of 0·025 in. nickel (10 per cent. of the total thickness), is satisfactory for most requirements, and this thickness of plate is standardised for many applications. Plates down to $\frac{3}{16}$ in. can be rolled, but to ensure adequate protection of the steel at this thickness the nickel layer is maintained at 0·025 in. Standard thicknesses in excess of ¼ in. are available in steps of $\frac{1}{16}$ in. up to ½ in., and in steps of ⅛ in. from ½ in. to 1 in., the thickness of nickel being progressively increased to a maximum of 0·060 in. for 1-in. thick plate.

Applications of Nickel-clad Steel

Caustic Alkalies.—It has been the general practice to use relatively cheap materials for the transport and storage of caustic alkalies, and since these materials have an imperfect resistance to caustic substances, the result has been that absolutely pure caustic has not been readily available. To obviate this disadvantage considerable use has been made of pure nickel, which, as is well known, has a very high resistance to caustic alkalies of all types. The relatively high cost of this metal has, however, limited its use. Nickel-clad steel, whilst having the advantage of the resistance of pure nickel, is available at an economical cost, and the obvious possibilities of this material for manufacturing and maintaining an uncontaminated caustic are therefore of immediate interest.



Specimen pieces of nickel-clad steel which have been twisted to test the bond between the nickel and the steel.

In many cases the problem of water storage is acute. A particular instance of this is the water storage heater in common use in laundries. False linings, either metallic or non-metallic, are unsatisfactory, and trouble, due to flaking or breakdown of the protective coating, is frequently encountered. When stored in steel vessels water often takes up iron in sufficient quantity to cause subsequent rust spots on the linen. Water is without effect on nickel, and rust is entirely absent in water from a tank in nickel-clad steel, which is ideally suited to this purpose. Wherever it is desired to store water without risk of trouble arising due to contamination, such as in dye-houses, bleacheries, breweries, water-softening plants, and in institutions such as hospitals, which require to store pure drinking water, the use of nickel-clad steel offers many real practical advantages.

In the textile industry the applications of this composite material are almost unlimited. Typical examples of its use are viscose refining and homogenising tanks used in the artificial-silk industry, dye-stuff mixing tanks, dye tanks, and other parts of dyeing plant, peroxide bleaching kiers, size-mixing kettles, and transport tanks used in connection with cloth weaving, and, of course, for any plant handling caustic soda.

Apart from its suitability for handling caustic alkalies, nickel-clad steel has further uses in soap manufacturing equipment. It is in use for soap-cooling plates, for storage tanks, and for soap-boiling kettles. Pressure vessels for handling palm oil are also being made in this composite material. In all its applications for handling soap, or soap products, the nickel surface ensures that no harmful metallic impurities shall enter and impair the quality of the soap.

It will be appreciated that the applications mentioned merely indicate a few instances where nickel-clad steel is at present found to be of value. There are many further cases where its use is economical.

Fabricating Nickel-clad Steel

Cold operations such as bending, flanging, forming, shearing, bevelling, and the like, are performed exactly as in ordinary steel-plate work. If the cold working is severe, such as in pressing heads and die work, plates softened by annealing are generally required. Heating the plate to a temperature of 870°—930° C., holding at this temperature for two or three minutes, and cooling in air gives satisfactory annealing, providing the necessary precautions are taken in the furnace.

Nickel is very susceptible to attack by sulphur-containing furnace atmospheres, and both during annealing and heating prior to hot-working it is essential to see that the furnace conditions are correct. Only fuels low in sulphur should be employed, and the work should not be allowed to come into direct contact with a strongly oxidising flame. It is advisable, therefore, to keep the nickel face downwards. If suitable furnaces are not available it is possible to overcome adverse conditions by placing the plate, nickel face downwards, in a flanged disc with a layer of 10/1 lime-charcoal mixture in the bottom. The liberal use of this mixture helps to protect the comparatively thin nickel surface from sulphur attack. Given the proper means of heating, and this is of prime importance, usual steel practice as to temperatures, amount of work done, and methods used can be safely followed.

During annealing and hot-working the nickel surface will become oxidised, and to remove the oxide formed, a paste pickle has to be employed. The following formula is suitable :—

Lampblack	1 lb.
Fullers earth	10 lb.
Hydrochloric acid, 20° Be	3 gals.
Nitric acid, 38° Be	½ pt.
Cupric chloride	1–2 lb.

It is better to apply the mixture warm, and for complete pickling several hours are necessary.

Welding

Joining methods are of especial importance in fabricating plant from nickel-clad steel. The nickel surface must remain unbroken, and continuity is obtained by welding with nickel. This material is usually welded by the metallic arc method, though the other recognised methods may be used if precautions are taken. The complete weld consists of a steel weld on one side and a nickel weld on the nickel side. If the nickel weld is peened, the physical properties are improved and a dense structure assured. Some care must be exercised in the welding of the nickel joint, and it may be advisable for the operator not acquainted with this type of weld to make a few trial welds on properly prepared test pieces.

The welding of the steel section, whether lap, fillet, or butt welding, presents no difficulty to the operator accustomed to such work. In butt welding, most of the weld metal is deposited in the " V " made by bevelling from the steel side to almost the full section of the plate. On the nickel side the joint is prepared by chiselling away the slag and oxidised metal at the base of the steel weld. The oxide scale is also removed from the adjacent nickel surface, preferably by grinding, to within about ⅛ in. on either side of the seam. After the slag and oxide have been removed the following points should be observed: with reasonable attention to these points a skilled operator will have no difficulty in obtaining a finished weld.

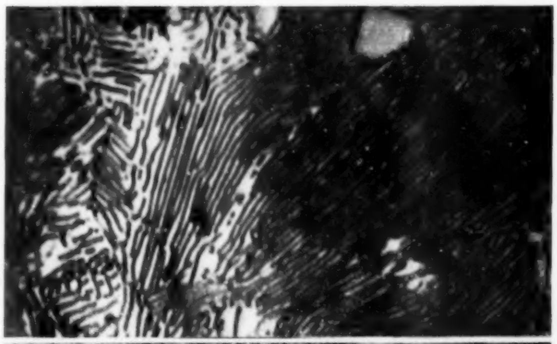
(*Continued on page* 158.)

Cast Iron for the Manufacture of Glass Bottle Moulds

The use of expensive alloy irons for the manufacture of glass bottle moulds cannot usually be justified because of cost, but high-quality refined pig irons are well suited for the purpose. Two grades of these refined irons should be stocked in order to control the silicon content.

MANY factors govern the choice of materials for making glass-bottle moulds. The material requires to have good casting and machining properties, and be capable of taking a fine polish, and, at the same time, must be resistant to heat and should scale as little as possible. From among the numerous highly-alloyed irons now available, such a material could doubtless readily be selected. But cost is an important factor, and, in a paper on the subject by Messrs. N. L. Evans, W. Goacher, and J. E. Hurst, read at a recent meeting of the Society of Glass Technology, by Mr. Hurst, it was stated that the use of expensive alloy irons cannot usually be justified, because very satisfactory results can be obtained by the use of properly-selected refined pig-irons.

Fig. 1.—Normal structure of a pearlitic cast iron. × 2,550.



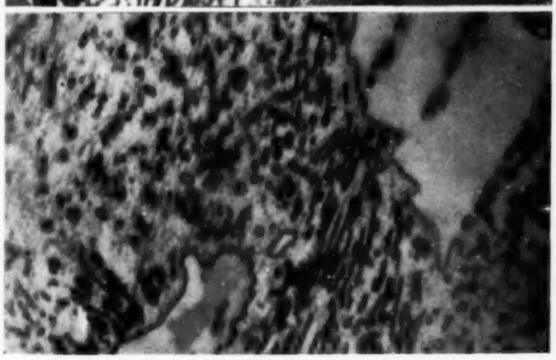


Fig. 2.—Same iron as Fig. 1, after being heated at 650° C. for 250 hrs The cementite layers of the pearlite are becoming spheroidised. × 2,550.

Fig. 3.—Graphite in cast iron which has grown. × 500. Note the hair-like excrescences and irregular edges on the graphite flakes.

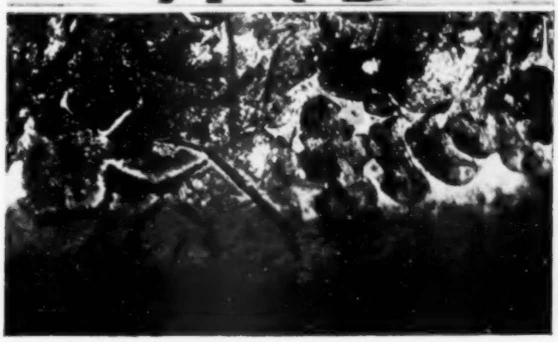


Fig. 4.—Section including the edge of a bottle mould after service. × 200. Note the oxide layer and the decarburised layers around the graphite flakes near the edge.

The moulds considered in this paper are the "Parison" mould and the blow mould, but the data on suitable irons are applicable to all moulds used in the glass industry. The glass entering such moulds has a temperature of 900-1,000° C., and the moulds themselves reach a temperature of approximately 500° C. on the inside. The skin temperature on the inside, however, must be much higher than 500° C., while the hot glass is actually in contact with it, as it is sufficient to cause scale to form on the iron. As the moulds are air-cooled on the outside, there is a considerable temperature gradient between the inside and the outside which sets up fairly considerable stresses in the iron.

Moulds in continuous use last longer than those used intermittently for making the same number of bottles. This is explained by the mechanism of growth in cast iron. Growth is due partly to the breakdown of iron carbide in cast iron, which takes place at a temperature of about 600° C. or over. The stable condition of cast iron is a mixture of iron and graphite, and the change to this from iron carbide is accompanied by an increase in volume, the density of iron carbide being about 3½ times that of graphite. Growth tends to start cracks in the iron which act as channels along which oxidation will occur, causing still further increase in volume: alternate heating and cooling accelerates the formation of cracks on account of expansion and contraction. Graphite flakes which penetrate to the surface of the iron will also act as channels for oxidation.

When using refined irons for making glass bottle moulds, the composition should be adjusted to minimise growth. The total carbon content of the iron should be low in order that graphite flakes may be as small and as few in number as possible. The silicon should be present in sufficient amount relative to the thickness of the castings to produce approximately an all pearlitic structure, that is, with no ferrite or iron carbide in the free state. The Brinell hardness of such an iron is usually between 215 and 235, and it can be readily machined. It is recommended that the phosphorus should not exceed 0·45%, as there is some evidence that this element in larger proportions has a deleterious effect on iron subjected to high temperature.

Manganese should be fairly high, as it helps to produce a fine grained structure, and sulphur should be kept as low as possible, and not exceeding 0·07%. While it is

true that sulphur tends to stabilise iron carbide, its tendency to segregate in the form of mixed iron and manganese sulphides often produces unsoundness in the casting, and hard patches difficult to machine.

Fig. 5.—Untreated iron. × 200.

Fig. 6.—Iron treated by the sodium carbonate process. × 200. Note the refined graphite and the comparative absence of non-metallic inclusions.

The sodium carbonate process for reducing the sulphur and refining the structure of the metal is fully described. This process agitates the metal in the ladle, thus assisting the removal of dissolved gases ; and the slag has a scouring action removing undesirable non-metallic inclusions. Most refined irons receive this treatment in the course of manufacture, and it need not be repeated if the metal is crucible

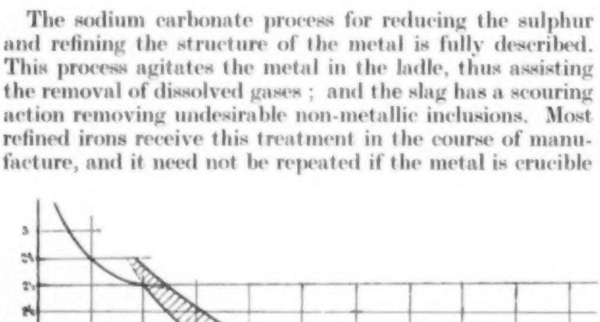


Fig. 7.—Chart showing silicon percentage and thickness of casting for glass-bottle mould castings.

melted for making the castings, but if it is melted in the the cupola it is very desirable that the re-melted iron should be treated in order to counteract the absorption of gases and the sulphur pickup from the coke, which are practically certain to take place by this method of melting.

It is worth noting that for crucible melting, refined irons can usually be obtained in the form of specially small pigs, more convenient than the usual larger pigs.

A suggested specification for iron for glass bottle moulds is as follows :—

Total carbon	3·1% maximum.
Silicon	according to thickness of casting.
Sulphur	0·07% maximum.
Phosphorus	0·45 maximum.
Manganese	0·8 to 1·5%

The variation in silicon content in relation to the prevailing thickness of the casting is shown by a chart, and the method of calculating the correct proportions in which to mix different grades of refined pig-iron is fully explained, both for cupola and crucible melting.

A.S.T.M. Tentative Standards 1935 Edition

This annual publication of the American Society for Testing Materials is the only volume containing all of the A.S.T.M. tentative specifications, methods of test and definitions of terms covering engineering materials and the allied testing field. These tentative standards, embodying the latest thoughts and practices, are widely used throughout industry. The 1935 edition contains 290 tentative standards. Of these 75 are included for the first time, while some 65 were revised this year and are given in their latest approved form. A general classification of the contents is as follows :—Ferrous metals (forgings, castings, pipe, etc.). Non-ferrous metals. Cementitious, ceramic, concrete and masonry materials. Paints, varnishes, lacquers and paint materials ; waterproofing and roofing materials. Petroleum products and lubricants. Road materials. Rubber products ; textile materials ; electrical insulating materials and miscellaneous materials and general methods.

New Tentative Standards.—New tentative specifications published for the first time in 1935 cover the following ferrous and non-ferrous materials :—Seamless steel still tubes for refinery service, seamless steel heat-exchanger and condenser tubes, steel pipe flanges for general service, heat-treated carbon steel and alloy-steel-track bolts, carbon steel and alloy-steel castings for railroads, steel castings for miscellaneous uses, uncoated and zinc-coated wrought iron sheets, electrodeposited coatings on steel, several types of chromium and chromium-nickel steel castings and sheets, lead-coated sheet copper, lead- and tin-base alloy die castings, phosphor-bronze plates for bridges and structures. Three new methods of spectrochemical analysis of various non-ferrous metals are given also.

In the non-metallic materials fields new specifications cover concrete irrigation pipe, soils (several methods of testing), basic sulphate blue-lead, shellac (testing), hiding power of white pigments, pile floor covering, wool (fineness test). Other products covered by new tentative standards are coal (grindability tests and screen analysis), vulcanized rubber (physical and adhesion tests), rayon woven fabrics, cotton fibres.

Revised Specifications.—Extensive revisions have been made in 1935 in the requirements for carbon-steel plates for boilers and other pressure vessels, cold-rolled strip steel, high-tensile strength plates, alloy-steel castings for service at 750–1,100° F., timber piles, building brick, concentric lay copper cable, bronze trolley wire, and other materials. In addition to the 290 A.S.T.M. tentative standards, this book includes all proposed revisions of standards, which are published to elicit criticism before final adoption. Changes in some 35 standards have been proposed.

To facilitate the use of the book, a complete subject index has been included, listing items under the materials and subjects to which they apply ; and two tables of contents are given, one listing the standards in the order they appear (grouped under general subjects) and the second listing the items in numeric sequence of serial designations.

Copies in cloth binding at $8·00 each, or in heavy paper cover, $7·00, can be obtained from A.S.T.M. Headquarters, 260 S. Broad-street, Philadelphia, U.S.A.

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THE STATELIEST SHIP

The Last Word in Shipbuilding

In a few weeks the *Queen Mary* will arrive at Southampton to prepare for her maiden trip on May 27. When she begins her trip across the Atlantic to New York it will be a red-letter day for the British nation, and the people of Clydebank in particular. Her launch, about eighteen months ago, opened another chapter in the history of the transatlantic passenger traffic in which British-built ships have made substantial contributions. It may be recalled that the *Mauretania*, which was recently sold to shipbreakers, held the Blue Riband of the Atlantic for 23 years with a crossing in four days 10 hours and 41 minutes. This honour was wrested from her by the *Bremen*, which lowered the time by three hours. It is confidently expected that the *Queen Mary* will, in due course, take the place held so long with honour by the *Mauretania*.

The keen rivalry and competition which has been associated with this traffic for so many years has served as a continual stimulus to development and progress, and the Blue Riband of the Atlantic is a synonym which has come to be recognised as associated with shipbuilding progress. The construction of such a huge vessel as the *Queen Mary* represents the most stupendous task that has ever been entrusted to shipbuilders and marine engineers.

At the launch of this vessel by Her Majesty the Queen, King George spoke of sending on her way the stateliest ship in being, and all who have seen her comment on the stateliness of this mammoth liner ; but the *Queen Mary* is more than that, she is the finest vessel made by any maritime race in any age. She embodies the accumulated skill of a thousand years of British shipbuilding and navigation. She embodies the very latest ideas in speed, safety and comfort. The progress of almost every branch of industry is represented in her construction ; almost every refinement of science and mechanism has been absorbed by the shipbuilders and engineers to make the *Queen Mary* the last word in shipbuilding.

The policy pursued by the builders has been to take advantage of the latest developments in materials and machinery to build what it is hoped will prove the fastest liner on the high seas, and it seems certain from the tests already made that she will ride the waves more swiftly and steadily than any ship yet built. It is fully expected that, in a relatively short time after her first trip, she will make the Atlantic crossing from Cherbourg in 96 hours which will mean the restoration of the Blue Riband, now held by the French *Normandie*, to a British liner.

The ship is designed to accommodate 4,000 persons, about 1,500 of which will be officers and crew. She has a sloping stem and a cruiser stern. She carries the usual fore and aft rig, and three large funnels of suitable rake and height to insure that the funnel gases will clear the promenades on the superstructure decks. In all she has 12 decks, comprising the sun deck, the upper promenade deck, the promenade deck, and "A" to "J" decks, including the partial lower decks, which are discontinued in the way of the machinery spaces. The principal subdivision is effected by 18 transverse bulkheads, while the double bottom, covering the whole length of the hull, contains 70 main compartments. If account is taken of the additional subdivision afforded by the inner shell, the engine rooms, and the side oil bunkers in the boiler rooms, there is a total number of 160 watertight compartments below the bulkhead deck ; it will thus be seen that the question of strength and safety has been met in compliance with the latest and most recent scientific investigations into hull structures. The question of materials was also carefully investigated, and many different types of steels decided upon to satisfy requirements in different parts of the structure.

It is probably appropriate to discuss whether a vessel of the dimension of the *Queen Mary* will pay. Obviously ships built to transport goods or passengers are expected to return a profit, and Lord Runciman, who has been running ships for profit these last 50 years, declares the *Queen Mary* will not pay. If, he said, she had been divided into three ships, there would have been more value in construction and more than 50 times the profit in sailing. It is probably true to say that by far the greater portion of those engaged in shipping agree with Lord Runciman, but quite a number of well-informed people believe that the *Queen Mary* will prove to be, if not so great a commercial as a constructional triumph, at least a sound proposition.

It should be remembered that the *Queen Mary* provides a standard of luxury and comfort undreamed-of 20 years ago, which will ensure her the cream of the traffic. Her potential earnings are enormous. On 20 round trips, for instance, she is capable of earning over £3,000,000 in fares. In addition, she will draw a substantial sum from mails and high-class freights, which will increase her potential revenue considerably. No one imagines that the maximum bookings will be taken over the whole year, or even during the summer season, but the supporters of the big-ship policy fully expect that her earnings will give a reasonable margin, despite heavy running expenses. Let us hope that, even if the optimism of these supporters is not entirely fulfilled, at least there will be a profit sufficient to justify the expense involved and the courage shown.

From a national point of view the cash return is not so important as the value of this vessel to British shipbuilding, so long as she comes up to expectations as a triumph of shipbuilding and design, because it is something to have built the stateliest ship in being and the best that ever sailed the seas.

With the departure of the *Queen Mary* from the Clyde a big gap will be left, and whatever the prospects are of a sister ship being built—as was contemplated when the keel for the *Queen Mary* was laid—considerable time must elapse before a decision is made, so that the Clyde will suffer a substantial loss. Fortunately, shipbuilding has improved considerably since this vessel was commenced, and the majority of the workmen will be readily absorbed. Should it be decided to build a sister ship from an economical point of view, it seems likely that the keel will be laid on the same slipway, and the same men will covet the honour of using their skill in such an important British enterprise.

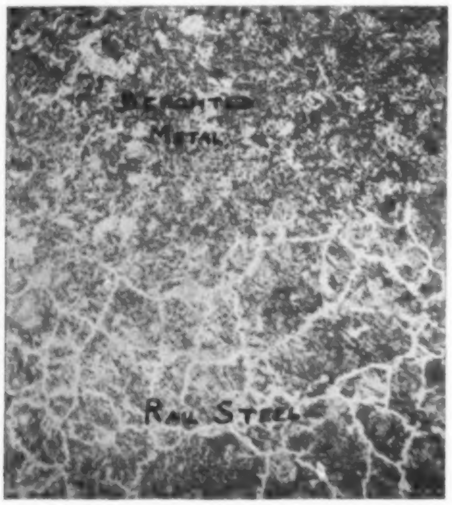
Correspondence

Rail Steel and Rail Wear

The Editor, METALLURGIA.

Sir,—I read Mr. Sanderson's article in the February issue of your Journal with much interest, and it occurred to me that you might be good enough to publish this letter from me in your columns, for the benefit of other readers.

On page 114 of your Journal it is stated: "Trouble is sometimes experienced in railway crossings through the wearing of the tongue and wing rails, made from rails in the usual manner. The repair of these by the deposit of hard metal by the oxy-acetylene process is not a satisfactory process. The metal deposited is usually very brittle, and the heat from the flame has a tendency to distort the rail and set up strain. As an alternative, this building-up process can be carried out by electric welding, using material ranging from 140 to 300 Brinell. A material should be chosen which deposits a metal about 200 Brinell, as this will be rather more plastic than is the case with some of the harder steels."



Micrograph of deposited metal on rail steel.

It is my intention to point out here that for the past two years excellent results have been obtained in service from carbon steel rails (having the chemical composition limits quoted by Mr. Sanderson) that have had their surfaces built up by the oxy-acetylene method, and great satisfaction has been expressed by those concerned. No brittleness has been noticed in the deposited metal, and no distortion, such as Mr. Sanderson suggests, has occurred.

These facts, of course, do not necessarily suggest that Mr. Sanderson's remarks have no foundation, but they do suggest that either he has not studied modern oxy-acetylene rail surfacing, or has been misinformed.

As carried out for the last two years, resurfacing of worn rails by the oxy-acetylene process results in a very tough deposited metal having a Brinell hardness of 250 to 300. The enclosed micrograph at a magnification of 100 diameters shows the microstructure of a rail resurfaced by the oxy-acetylene method, and it can be seen that the deposited metal has a Sorbitic structure. As the Sorbitic condition in steel is the toughest condition, brittleness does not accompany the Brinell hardness of 250 to 300, but, instead, great resistance to shock and crack formation.

I am quite sure that readers of your Journal will be interested in the little information given here, as the particular welding rod used for rail-surfacing by the oxy-acetylene method has many other applications where resistance to shock and toughness is required to accompany resistance to wear.—Yours, etc.,

February 29, 1936.

L. C. PERCIVAL,
Technical & Research Dept.
Metallurgist,
The British Oxygen Company, Ltd.

Forthcoming Meetings

THE ROYAL AERONAUTICAL SOCIETY.

Mar. 23. "The Jointing of Materials by Welding," by Mr. R. H. Dobson.

THE INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Mar. 31. Annual Meeting: Chairman's Address by Dr. Maurice Cook.

April 2. "Recent Developments in the Casting of High-Strength Zinc-Base Alloys," by Mr. A. H. Mundey.

LONDON SECTION.

April 9. Annual General Meeting and Open Discussion.

NORTH-EAST COAST SECTION.

April 7. Demonstration of High-Frequency Induction Furnace.

ANNUAL GENERAL MEETING.

MANCHESTER METALLURGICAL SOCIETY.

Mar. 18. Annual Meeting.
Open Discussion led by Mr. E. W. Colbeck on "Materials and Maintenance of Lifting Gear."

ELECTRODEPOSITORS' TECHNICAL SOCIETY.

April 7. "Pre-Treatment of Metal for Final Finishing." by Mr. B. C. Taylor, in Birmingham.

April 15 "Pickling and Plating Brittleness of Steel," by Mr. H. Sutton, in London.

INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM BRANCH.

April 3. Annual General Meeting.
Short Paper Competition.

EAST MIDLANDS BRANCH.

Mar. 28. Annual General Meeting.
Members' Problems.

LANCASHIRE BRANCH.

April 4. Annual General Meeting.
"Foundry Refractories," by Mr. W. J. Rees.

LONDON BRANCH.

April 1. Annual General Meeting.
Short Paper Competition.

MIDDLESBOROUGH BRANCH.

Mar. 20. "Some Aspects of Coke Making," by Mr. W. Scholes.

NEWCASTLE-ON-TYNE BRANCH.

Mar. 17. "Foundry Costs," by Messrs. S. G. Homfray, and R. A. Balderston.
Joint Meeting with the Institute of Metals.

SHEFFIELD BRANCH.

Mar. 26. I.—Visit to the Works of Kelton Portland Cement Co., Ltd., Kelton.
II.—"The Manufacture of Portland Cement (Mechanical Processes)," by Mr. J. H. Billson.

WEST RIDING OF YORKSHIRE BRANCH.

April 4. "Oil Engine Castings," by Mr. H. E. Beardshaw.

Personal

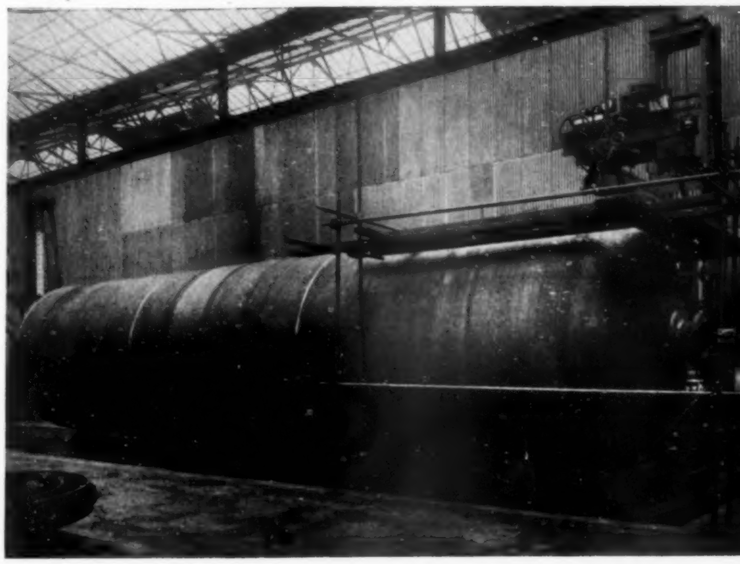
It is announced by English Steel Corporation, Ltd., that Mr. A. G. E. Briggs, Special Director and Sales Manager of that Company, is appointed a Director of the Darlington Forge, Ltd.

The United Steel Companies, Ltd., inform us that Messrs. S. A. Jackson and G. R. Bolsover have been elected Directors of Messrs. Samuel Fox and Co., Ltd., Stocksbridge, one of the associated companies.

We learn that Mr. William Reid, General Manager of Davy Brothers, Ltd., of Sheffield, who are well known as manufacturers of Steel Works Plant and Forging Machinery has just returned from a visit to the United States, where he has been inspecting the latest types of four-high continuous-roling mills in use in that country. Mr. Reid has, we understland been making arrangements to manufacture certain types of plant in this country to American latest designs, and this should be of interest to British steel makers.

Fusion-Welded Pressure Vessels

Numerous welded-pressure vessels, including boiler drums, steam containers, chemical reaction chambers, air receivers and refrigeration plant have been constructed. Many important details in their construction were presented in a paper at a meeting of the Institution of Petroleum Technologists, and more recently at a meeting of the Manchester Metallurgical Society, by Dr. S. F. Dorey, an abridgement of which is given in this article.



A propane storage tank made by Messrs. Babcock and Wilcox Ltd. 10 ft. internal diameter by 40 ft. long. Working pressure 280 lb. per sq. in. The circumferential seam is shown in the course of welding.

DURING the past two or three years such progress has been made in autogenous welding processes and apparatus that the Committee of Lloyd's Register of Shipping has deemed it not only prudent but necessary to make provision in the Rules for the acceptance of fusion-welded pressure vessels. In 1934, the Society's rules for boilers and unfired pressure vessels such as air receivers were revised and fusion welding by the electric arc or oxy-acetylene gas process is now no longer prohibited for plates in tension. Although no published rules have been issued governing the welded construction of pressure vessels intended for marine purposes, such rules will be promulgated in due course; in the meantime the Committee is in a position to give proposals very careful and authoritative consideration and to treat each individual case on its merits.

Activities in connection with non-marine work have increased considerably during the last year or so, and it has been found necessary to legislate for the welding of pressure vessels intended for land purposes. Accordingly, in 1934, the Society published "Tentative Requirements for Fusion-Welded Pressure Vessels intended for Land Purposes," and since that date numerous welded-pressure vessels, including boiler drums, steam containers, chemical reaction chambers, air receivers and refrigeration plant have been constructed under survey. Dr. Dorey considers it safe to say that without welding some of the latest advances in steam generating plant could never have been made. In his paper he confined himself to a discussion of some of the important factors concerning the welding of pressure vessels.

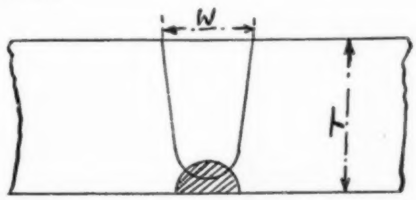
The Patent Plate Material

One of the first considerations in regard to the manufacture of fusion-welded boiler drums is the selection of the parent-plate material. Emphasis has frequently been laid on the necessity for providing weld metal which after deposition will possess the same chemical and physical properties as the parent plate. At the same time, it is not always realised that the desired complete identity of parent plate with weld metal as deposited is quite impossible to obtain. The fact will always remain that weld metal is cast metal, while the parent metal is wrought. There is thus a fundamental difference in metallurgical condition, apart from chemical composition, which can be modified only by subsequent heat-treatment.

There are three main factors to bear in mind: The effect of differential freezing during welding; the possibility of electrolytic action in service, and the strength properties of the joint.

It is not difficult to understand that when molten weld metal is run between the solid surfaces of two adjoining steel plates, these surfaces are themselves reduced to a molten condition, and an intimate mixing of the two fluids takes place. The fusion zone of a welded joint consists, therefore, of a diffusion of constituents of the parent metal into the weld, and vice versa. It is for this reason that special consideration must be given to the chemical composition of steel plates intended for welding.

Carbon is the most important strength-giving constituent in steel, and experience indicates that up to 0·4% carbon content there is no special difficulty in effecting a satisfactory ductile weld. Boiler quality mild-steel plate may contain between 0·1% and 0·2% carbon, depending upon the tensile strength required. Arc welding has a decarburising effect on the plate immediately adjacent to the weld, and it is possible, therefore, to cause a slight reduction in tensile strength in this position. Certain elements such as manganese and silicon may be introduced through the medium of the electrode and serve to prevent excessive decarburisation.

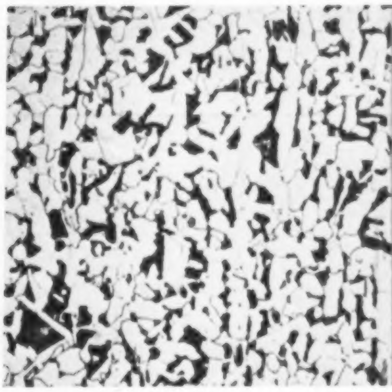


SHADED PORTION TO BE CUT OUT AND WELDED UP FROM UNDERSIDE.

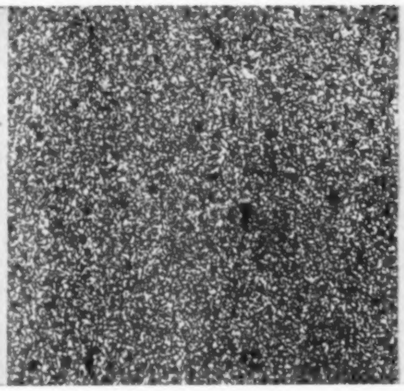
	In.	In.	In.	In.	In.	In.	In.	In.
T	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
W	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{29}{32}$	$\frac{15}{16}$

Type of Joint for fusion-welded boiler drums.

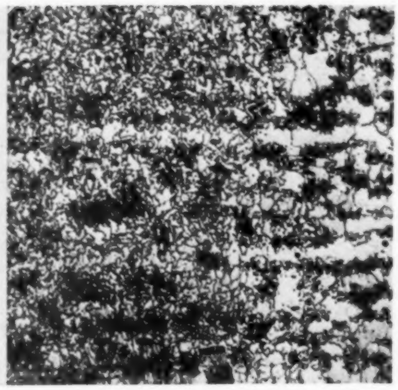
Both manganese and silicon are powerful de-oxidising agents, and when contained in the electrode they are substantially reduced in quantity during the process of deposition. Manganese has a toughening effect on mild steel, and is generally present in proportions up to about 1·0%. In considering the favourable effect of manganese,



Micrograph of rolled mild-steel boiler plate × 100.



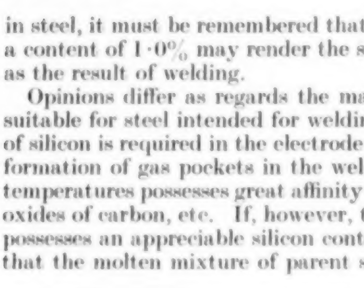
Micrograph showing fusion weld at centre of joint. × 100.



Micrograph of fusion weld showing junction between plate and weld metal. × 100.

in steel, it must be remembered that a slight increase above a content of 1·0% may render the steel prone to hardening as the result of welding.

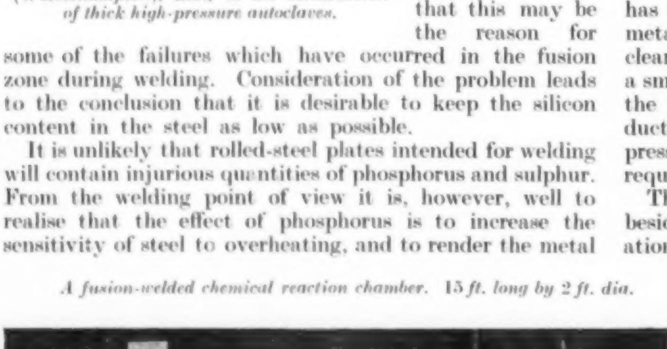
Opinions differ as regards the maximum silicon content suitable for steel intended for welding. A certain quantity of silicon is required in the electrode in order to prevent the formation of gas pockets in the weld metal, which at high temperatures possesses great affinity for hydrogen, nitrogen, oxides of carbon, etc. If, however, the parent steel already possesses an appreciable silicon content, it appears possible that the molten mixture of parent steel and weld metal in the fusion zone may be unduly "killed" during cooling and the resultant solid metal at the weld junction will be brittle and, having regard to the increased rate of contraction during solidification, would be prone to cracking. In these circumstances Dr. Dorey suggested that this may be the reason for some of the failures which have occurred in the fusion zone during welding. Consideration of the problem leads to the conclusion that it is desirable to keep the silicon content in the steel as low as possible.



Form of joint used by Messrs. John Thompson (Wolverhampton), Ltd., in the construction of thick high-pressure autoclaves.

It is unlikely that rolled-steel plates intended for welding will contain injurious quantities of phosphorus and sulphur. From the welding point of view it is, however, well to realise that the effect of phosphorus is to increase the sensitivity of steel to overheating, and to render the metal cold short and brittle. Sulphur, on the other hand, renders the steel red short—that is to say, brittle when it is hot. So far as sulphur is concerned, the important consideration is not so much the quantity, but rather the condition in which it is present in steel.

A fusion-welded chemical reaction chamber. 15 ft. long by 2 ft. dia.



The Electrode

Of equal importance to the selection of the parent-plate material is the choice of welding rod or electrode which has to be melted down in order to provide the weld deposit. It is now generally understood that bare-wire electrodes are unsuitable for the welding of joints which require ductility, toughness and strength. This is mainly due to the complete absence of any protection of the molten weld metal from atmospheric contamination. What is not generally understood, however, is that the mere fact that an electrode is covered does not mean that the electrode is any more suitable for its purpose than bare wire. It does not follow that if the arc stream and deposited weld metal are shielded from atmospheric contamination, oxidisation of the weld is automatically prevented, since some electrodes may have what is called an oxidising coating—that is a thick covering in which the concentration of oxygen may even be greater than could be obtained with bare-wire electrodes.

These thick coated or heavily fluxed electrodes include in the siliceous material of the covering considerable quantities of ferric oxide. The weight of the flux in these cases has the effect of ironing out the molten and plastic weld metal, so that the resultant finish of the weld is smooth and clean. Such electrodes are specially suitable for producing a smooth, concave contour in fillet welds, but unfortunately the weld metal is highly oxidised, hard, and lacking in ductility. They are quite unsuitable for the welding of pressure vessels, although they fully comply with the simple requirement that electrodes should be covered.

The electrode covering has other important functions besides the shielding of the arc from atmospheric contamination. In this connection, reference might be made to the importance of ferro-manganese, a de-oxidising agent producing an exothermic reaction which has the effect of retarding the rate of cooling of the molten pool, thus giving the gases and inclusions time to escape before solidification of the weld metal commences. Such exothermic reactions increase the speed of welding because of the increased melting off rate of the electrode, the welding heat being provided from two sources—viz., the electric energy in the arc and the heat generated by chemical reaction.

For vertical and overhead welding a quick freezing weld metal must be deposited and the practical considerations governing the making of welds in these positions preclude the use of heavily fluxed shielded arc electrodes. For these reasons

the welding of important pressure vessels should always be done in the flat underhand horizontal position.

There need be no special difficulty in selecting an electrode suitable for the welding of these vessels, provided the essential requirements are understood and strictly enforced. For their selection the following requirements are suggested for consideration :—

(1) *Type of electrode.*—The electrode should be of the type which provides a reducing gas shield to the arc and a neutral slag over the deposited weld metal. It should be easy to manipulate, non-spluttering and capable of maintaining a steady arc and uniform melting rate. The slag should be easily removable from the surface of the weld metal after cooling.

(2) *Chemical analysis.*—It is thought that the electrode maker should be allowed a certain freedom in his choice of core wire for electrodes, and it does not seem to be in the interests of progress and development for the user to specify the exact chemical analysis of core wire and covering, or whether the core wire should be made from rimmed or silicon killed steel. It is, however, important that the desired chemical composition and mechanical properties of the weld metal as deposited should be clearly defined within reasonable limits. Consideration of the analysis obtained from a number of high-quality weld deposits made in low-carbon mild steel plate suggests that the following percentages for the various elements in weld metal might form a reasonable basis for comparison :—

Composition.	
Carbon	0·06–0·12%
Silicon	0·05%
Manganese	0·4–0·5%
Phosphorous	0·015% max.
Sulphur	0·015% max.
Nitrogen (Total)	0·015% max.
Oxygen (Total)	0·05% max.
Iron Oxide	NIL

(3) *Physical properties of weld metal.*—The quality of the weld metal as deposited from the electrode may be accessed by preparing test specimens from a sample joint made between boiler quality mild steel plates 1 in. in thickness.

An important factor in the choice of an electrode is ease of manipulation, and here reliance should be placed on the opinion of an experienced and trustworthy welding operator. It is, of course, impossible for many of those interested in the manufacture of welded products to make an exhaustive study of electrodes. There are many types available, good, bad and indifferent and some are more suitable than others for work of special character. The best advice that can be given is to deal with reputable electrode makers only, and it will be found that most of them will frankly admit the limitations of their different electrodes.

Welding Technique

Dr. Dorey stressed the importance of accurate " fit-up." The welding groove which forms the seam should be of the U form, as narrow as practicable and with the sides nearly parallel. Care should be taken to see that the butting edges are properly in line, and if there is any gap at all at the root of the joint, that it is consistent for the entire length of the seam. The plate edges to be welded should be machine cut, clean and free from the burrs sometimes caused during handling. Certain electrodes deposit weld metal sufficiently ductile to allow the complete butting of the plate edges without any shrinkage gap.

A backing strip should be tack-welded under the seam for the full length. The material and dimensions of this strip are unimportant, provided it is thick enough to withstand the impingement of the arc without burning. The longitudinal joint should be tack-welded at the root. By means of jacks the circular shell should be forced into an elliptical shape, the major axis being in line with the longitudinal joint. Struts should be inserted to hold the vessel in this shape until welding is complete.

On the completion of the welding of the longitudinal seam, the struts and backing strip should be removed, and

Welded cylindrical shell, 3½ in. thick, for high pressure autoclave, made by Messrs, John Thompson (Wolverhampton), Ltd.

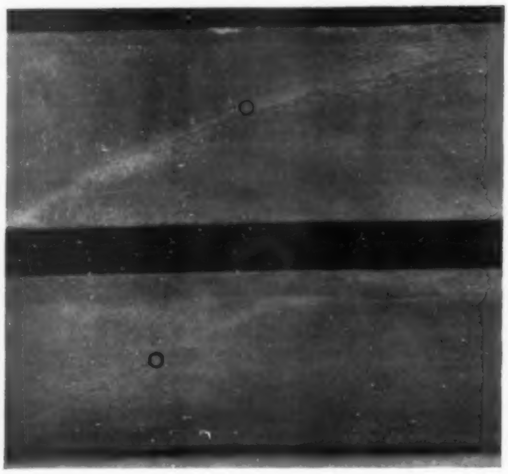
by means of a pneumatic chisel, a vee should be cut from the inside of the shell right along the seam. This will cut out practically the whole of the first run of weld metal deposited in the joint. It should be explained that this first run is contaminated from the underside, and usually contains trapped slag, cracks and blowholes. It may be regarded as doubtful metal and for important pressure vessels should be removed. On both the inside and the outside the weld should be built up so as to ensure the refining of the crystal structure throughout the full depth of the weld. The extra weld metal should subsequently be removed by grinding the weld flush with the parent plate.

It is important to arrange that all the welding be done underhand—that is, with the electrode vertical and the weld groove horizontal. For this reason, arrangements must be made so that in welding the circumferential seams the drum can be rotated. On no account must the welder be allowed to continue his run of weld metal round the circumference to such an extent that the molten weld metal runs in front of the electrode.

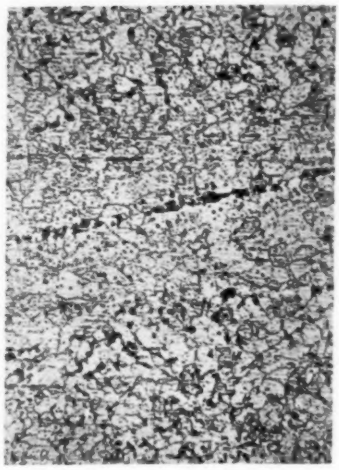
Manual and Machine Welding

A problem, which, sooner or later, faces all those concerned in the manufacture of fusion welded pressure vessels

Dished end plates for autoclave shown above. Each of these was pressed in a single operation.



Macrographs of lap joints made by water-gas welding.



Micrograph of water-gas weld. × 100.

The finished autoclave. Internal dia. 6 ft.; length 11 ft. 8¼ in.; shell plates and finished ends 3¼ in. thick. Working pressure 900 lb. per sq. in., working temperature 320° C.

is that of deciding whether manual or machine welding is best for their purpose. The use of a welding machine enables the employment of larger electrodes, higher welding currents and faster welding speeds. These are important advantages from the point of view of production. At the same time, it must be remembered that great accuracy must be maintained in the preparation and "fit up" of the vessel to be welded. In manual welding any slight inaccuracy in the joint can be observed by the welder, who can manipulate his electrode accordingly. From the economic point of view, therefore, it is necessary, when taking account of the increased welding speed, to make due allowance for the time and care required in fitting up the vessel preparatory to welding.

Technical considerations indicate that machine welding of the longitudinal and circumferential seams possesses distinct advantages over manual welding. In the first place, it is possible to maintain a standard set of welding conditions under which the consistency of the weld deposit can be ensured throughout the full length of the seam, there is no undue fluctuation of arc length, and, further, the operation of the machine does not induce the same degree of fatigue in the welder.

Residual Stress and Stress Relieving

The problems relating to residual stress in weld metal continue to receive considerable thought and study. A variety of methods of investigation have been adopted by different research authorities in their attempts to evaluate the magnitude of residual stress and the nature of its distribution.

Residual stress may be defined as the stress which exists in weld metal as the result of differential cooling. The stress may be complex in character and of varying intensity across any one plane. It is caused by the shrinking of cooling weld metal, and is aggravated when the metal is deposited between re-strained or partly re-strained plates.

It is often erroneously inferred that severe distortion is indicative of serious residual stresses. On the contrary, it is in the absence of distortion that serious locked-up stresses are likely to occur. The "fit-up" of any structure which is to be welded should, when possible, be such as to allow movement—*i.e.*, distortion to take place, so that the final shape of the distorted structure is the shape desired. In the case of pressure vessels this principle is applied by commencing to weld with the vessel constrained to an elliptical shape; the result of the distortion due to weld metal shrinkage is that the final shape of the vessel is approximately circular.

In regard to the stress-relieving treatments which may be applied to pressure vessels, there appears to be three methods worthy of consideration—*viz.*:—

(1) *Normalising*—*i.e.*, heating to above the upper critical temperature and cooling in a still atmosphere.

(2) *Annealing, or Stress Relieving*—*i.e.*, heating to a temperature slightly below the lower critical and cooling either in a still atmosphere or in the furnace.

(3) *Stress Relieving by Means of Mechanical Straining.* Dr. Dorey suggests that, in order to obtain the best condition of ductility in combination with toughness, the normalising heat-treatment should be followed by reheating to 600–650° C., and cooling in a still atmosphere or in the furnace. The usual practice in regard to the heat-treatment of pressure vessels is to subject them to what is termed a "stress relieving" treatment. This involves heating the vessel in a furnace to a temperature between 500° C. and 650° C., depending upon the requirements of some particular specification, or, in many cases, on the usual practice of the firm concerned. In the opinion of Dr. Dorey this practice is quite satisfactory for welded pressure vessels made from low carbon mild steel boiler plate and, while it is difficult to assess the magnitude of residual stress and the degree of stress relief afforded, there is no question that satisfactory results are being obtained by stress relieving at 600–620° C.

Testing and Inspection

The subject of testing and inspection was too big to be dealt with adequately in this paper, but Dr. Dorey dealt fully with it in a paper given in Group 4 of the Welding Symposium published by the Iron and Steel Institute.

A welded stabiliser tower made by Messrs. Babcock and Wilcox Ltd., 5 ft. 3 in. internal dia., by 65 ft. 6 in. long, shell thickness 1⅞ in.; intended for a working pressure of 400 lb. per sq. in.

The first difficulty which arises in the adoption of a testing and inspection procedure is the grading of pressure vessels in the order of their importance and vulnerability—*e.g.*, it would be quite unreasonable to apply the same tests to a low-pressure unfired water container as would be applied to a high-pressure boiler drum. Lloyd's Register consider pressure vessels under two heads—*viz.*, :—

Class I.—Fired pressure vessels and vessels subject to internal steam pressure above 50 lb. per sq. in.

Class II.—Pressure vessels not included in Class I.

The welding of the highest class of pressure vessels—namely, high-pressure boiler drums, autoclaves, etc.—is a specialised branch of the welding industry. The work is of such importance that, so far as Lloyd's Register is concerned Class I. pressure vessels can be accepted only provided they are made by approved firms who have carried out a comprehensive series of special tests to demonstrate the consistency and quality of their welding work.

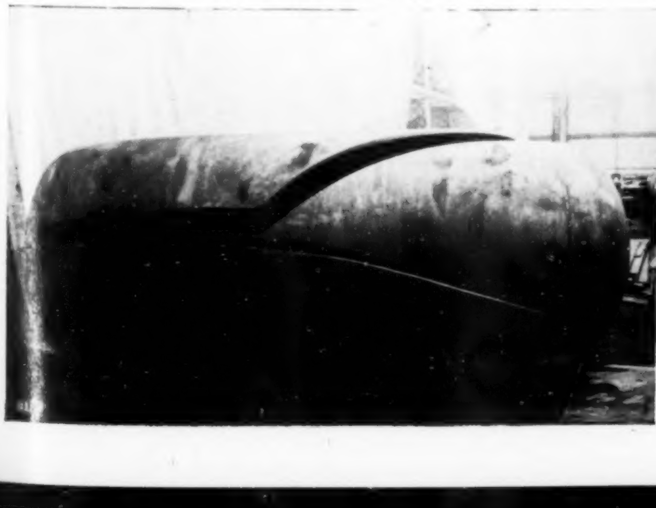
The routine testing of pressure vessels involves the welding up of sample test plates conjointly with the welding of the longitudinal and circumferential seams. For the former it is usual to attach the sample test plates at the ends of the seams, so that the sample joint forms a continuation and duplication of the seams. This arrangement has sometimes been criticised, and doubts have been expressed as to whether the test plates comprise a true sample and reproduction of the actual seam. The author recently had tests carried out on specimens cut from a sample test plate, and also on specimens cut from the actual welded longitudinal joints. It so happened that the tests on the sample indicated certain inherent defects in the weld, and this was confirmed by the tests made on the actual joint. This example affords an assurance that sample test plates welded conjointly with the joints of pressure vessels may reasonably be regarded as representative.

For the purpose of the routine assessment of the quality and strength of the welded joint, it has been found satisfactory to rely upon a series of simple and straightforward tests, namely :—All weld tensile ; transverse tensile, across joint ; transverse bend, across joint ; impact tests in weld and fusion zone.

For Class I. pressure vessels, in addition to these tests it is necessary to carry out density tests and to take photo-micro- and macro-graphs of a section of the weld. The microscopic examination must include the centre of the weld and the fusion zone. Further, the entire length of each of the welded seams must be subjected to X-ray examination, and finally, satisfactory results must be obtained from the application of the appropriate hydraulic and hammer tests to the finished vessel.

It is considered that with this testing procedure, combined with a very careful inspection at various stages in the construction of a pressure vessel, the production of safe and reliable welded joints will be assured.

Fusion-welded pressure vessel made by Messrs. Sulzer Bros., after being subjected to a bursting test. The vessel had spiral seams and rupture took place at 2,300 lb. per sq. in. The welded joints remained intact, the fractures being confined to the solid plate. Length 16 ft. 6 in. ; dia. 6 ft. ; plate thickness $1\frac{7}{16}$ in.



Mr. Fred Clements Awarded the Bessemer Medal

THE Bessemer Gold Medal —which is recognised as the highest honour within the gift of the Council of the Iron and Steel Institute —has this year been awarded to Mr. Fred Clements, M.I.C.E., M.I.Mech.E., Assoc. M.I.E.E., Director and General Manager of The Park Gate Iron and Steel Co., Ltd., of Rotherham, in recognition of his distinguished services in improving the technology of the iron and steel industries, and, in particular, blast-furnace practice. The medal, which was endowed in 1873 by the late Sir Henry Bessemer, the famous Sheffield steel manufacturer and inventor of the Bessemer Process, is awarded each year on an international basis in recognition of services rendered to the iron and steel industry. Numbered amongst past recipients are many of the leading figures in the industry both in Great Britain and abroad.

Mr. Clements, in addition to the active part he has played in the development of the Park Gate works to their present high standing amongst producing plants, has gained recognition as an expert in the iron and steel industry, and his opinion is sought as a consultant in many directions. His influence on technical progress, however, has been international by his contributions of the results of industrial research to the Proceedings of The Iron and Steel Institute. These were deemed in this country, and even to a greater extent in Germany and America, to introduce a new line of attack on industrial problems which has been followed since with considerable success.

In 1929 Messrs. Benn, Ltd., published, in three volumes, his work entitled " Blast Furnace Practice." This study, which reviewed the process of pig-iron manufacture in all the producing countries of the world, has had a wide circulation both at home and abroad. It is regarded as one of the most important additions to technical literature in this generation.

The presentation will be made by the President of the Iron and Steel Institute, Sir Harold Carpenter, F.R.S., at the opening session of the annual general meeting of the Institute, on the morning of Thursday, May 7, 1936.

The Tin Industry in 1935

Tin statistics in detail up to the end of 1935 have just been published in the February issue of the Hague statistical *Bulletin* of the International Tin Research and Development Council. Comparing the 1935 figures with those of the previous year, world apparent consumption increased by more than 20 per cent. from 117,681 tons to 141,524 tons. There was a very close agreement between the amount of tin produced in 1935 (139,053 tons) and the quantity used in manufacture (139,000 tons, approximately). A change in the policy of consumers is indicated by the fact that in 1935 there was an increase of about 2,500 tons in " invisible " stocks, while in 1934 there was a decrease of 12,300 tons. The total visible stocks of tin decreased during 1935 from 17,107 tons to 13,841 tons, but this decrease was largely offset by a rise to 16,052 tons in January of this year. The United States of America used 44 per cent. of the world's tin in 1935, compared with 37 per cent. in 1934.

With the exception of France (where there was a decrease of 12·2%), all the important countries increased their tin consumption appreciably in 1935. Consumption in the U.S.A. increased by 42·9% from 43,601 tons to 62,292 tons.

Welding and Welding Equipment at Metropolitan-Vickers

At the invitation of Metropolitan-Vickers Electrical Co., Ltd., a large number of the members of the Manchester Metallurgical Society visited the welding shops at Trafford Park, Manchester. The arrangement coincided with a lecture before the Society given by Dr. S. F. Dorey, of Lloyd's Register of Shipping, on "Fusion Welded Pressure Vessels." The works visit, being in advance of the lecture, gave members the opportunity of seeing the remarkable progress made in the welding of metals, and assisted discussion on the subject. They were able to see a very wide range of materials being welded in wqich the methods employed included metallic arc, both hand and automatic; atomic hydrogen, both hand and automatic; acetylene; spot; seam and flash-butt welding.

Metropolitan-Vickers are surely one of the largest welding firms in the United Kingdom, and the inspection of the various departments, in which welding was in progress, occupied nearly three hours. The amount and variety of work in which welding forms an important part must have been surprising to many, but it should be appreciated that Metropolitan-Vickers may be regarded as pioneers in the development of various welding processes, not only in the actual appreciation to their own structural work, but in the development of welding equipment and in the manufacture of electrodes.

The wide range of welding electrodes manufactured by this Company has recently been extended. Of the new types now available, probably the most interesting are the electrodes developed for the welding of thin plates and for the welding of stainless steel. For the welding of thin plates, electrodes down to 22-gauge have been developed and are now being widely used. The electrodes developed for the welding of stainless steel produce an austenitic decay-proof weld. Extensive experience and tests with corrosive agents demonstrate that the welded joint is not subject to preferential corrosive attack.

In the development of welding equipment this Company is well known, but it is noteworthy that two new welding sets have recently been developed which are of interest. The first is a d.c. welder, known as the "Paradyne." In this welder no exciter is used, a constant voltage to excite the shunt-field coils being obtained by means of split poles and a third brush on the commutator. The weight is considerably less than that of previous welding sets, and this, together with the compact design, makes for portability and ease of handling. The control gear is housed in a compartment on top of the machine, and has a plug-and-socket type selector, which has the great advantage over the usual sliding contact type of being positive and definite in action. Four tappings are provided, giving a range of welding current between 15 and 300 amperes. The maximum rating for continuous hand-welding service is 200 amps., the machine being capable of giving a current of 300 amps. for jobbing purposes. Tests have shown that the arc is stable yet lively on all current ranges, and while there is an adequate current surge to ensure easy striking, yet the instantaneous short-circuit current is not so great as to cause "freezing" of the electrode to the work.

The second welder is one designed to be specially suitable for welding thin plate. For this type of work high-frequency alternating current has been shown to give the best results. The set is designed for use on a 3-phase circuit, and has the great advantage that it imposes a balanced load on the three phases, whilst giving a single-phase current of 150 cycles for welding. The set, therefore, permits of welding by alternating current, while satisfying those supply authorities who will not allow a single-phase transformer equipment to be connected to their mains owing to the resulting unbalanced load on the system. The chief advantage of high-frequency alternating current for thin-plate welding is the elimination of troublesome magnetic effects which tend to extinguish the arc, especially at the beginning and end of the seam. Both primary and secondary windings are carried in the stator punchings, the former being a 2-pole winding and the latter a 6-pole winding. The rotor is of the two-salient-pole type, built up from punchings, and carrying a squirrel-cage winding. The welding current is varied by means of a drum controller and a variable reactor in the output circuit, coarse and fine variations of current being obtained respectively by these. A combination of these two adjustments makes it possible to obtain *any* value of current between 15 and 100 amps. No collecting device is required in the form of a commutator or slip-rings. The welding set which is known as the type "100A3" is suitable for continuous-welding service at a current of 100 amps.

It is also interesting to note that the atomic hydrogen process of welding has been further developed, and automatic multi-arc welding heads are in operation. These equipments employ three or six arcs simultaneously, and enable high welding speeds to be attained.

Reference to the Work of Joule

At the conclusion of the visit a vote of thanks to Metropolitan-Vickers Electrical Co., Ltd., was proposed by Mr. L. W. Schuster, and, in replying on behalf of the Company, Mr. R. W. Bailey mentioned that Joule, in 1855, invented electric welding of metals and proved its practicability. We are indebted to Mr. Bailey for a copy of a paper* given before the Institution of Mechanical Engineers, in which he made the following reference to Joule as the inventor of electric welding: "In 1856 Joule gave a paper to the Manchester Literary and Philosophical Society entitled 'On the Fusion of Metals by Voltaic Electricity.' In this paper Joule not only foresaw that in many instances the process would advantageously supersede that of soldering, but he envisaged the possibility of electric melting of iron, and estimated its cost. After calculating the amount of zinc necessary to melt iron Youle said the quantity of zinc consumed in the voltaic process is nearly equal to that of the iron to be melted, but it would be possible to effect the same object in a more economical manner by availing ourselves of the use of the magneto-electrical machine. This machine enables us to obtain heat from ordinary mechanical force, which mechanical force may again be derived from the conversion of heat, as in the steam engine . . . it is possible to arrange machinery so as to produce currents of electricity which shall evolve one-tenth of the quantity of heat due to the combustion of the coal employed. So that 5,000 grains of coal used in this way would suffice for the fusion of 1 lb. of iron."

This visit proved both interesting and instructive, for which much credit is due to Mr. Benson, who is a member of the Research Department of Metropolitan-Vickers Electrical Co., Ltd., and, incidentally, president of the Manchester Metallurgical Society, for the arrangements.

* R. W. Bailey: "The Contribution of Manchester Researches to Mechanical Science." Proceedings of I. Mech. E., 1929.

Institute of Metals

The Annual General Meeting in London

THE twenty-eighth annual general meeting of the Institute of Metals, held in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, on March 11 and 12, was well supported, including not only home members but several from overseas. Following the opening business meeting, at which new officers were appointed, the programme included a number of papers which were presented at technical sessions.

The new President, Mr. W. R. Barclay, O.B.E., was inducted into the chair by the retiring president, Dr. Harold Moore, C.B.E., and in his subsequent address he commented on the influence of the Institute. Its success, he said, does not lie in the fact that during the years intervening since its foundation its membership has grown from under 200 to well over 2,000, or that its income and expenditure is reckoned now in thousands instead of hundreds of pounds, but in the influence which it exercises to-day on non-ferrous metallurgy, not only in this country but in almost every civilised portion of the earth. This influence extends beyond anything its founders visualised.

THE DEVELOPMENT MOVEMENT IN MODERN INDUSTRIAL METALLURGY

The major portion of this address was devoted to the consideration of the post-war development movement in modern industrial metallurgy, which is still in a relatively evolutionary stage. The movement is founded on the idea that the best method of advancing the interests of the non-ferrous metal industries is to provide the ultimate consumer of metals with information, as up to date and accurate as possible, on the properties and applications of non-ferrous metals and alloys as affecting every field of their use, actual or potential. The movement has so far been developed chiefly in four sections of these industries, viz., aluminium, copper, nickel, and tin; but a number of firms concerned with other of the elementary metals, particularly zinc and lead, are now organising themselves in some degree for similar objects.

Mr. Barclay discussed in some detail the development of this movement in regard to these four sections, and stated that although differing somewhat in detail, the fundamental aim of all the organisations responsible for these sections is the same—*i.e.*, to circulate by publication and personal service reliable and detailed technical data and information relating to their respective "raw materials" of industry, in such forms and by such methods as will furnish the engineer and general user with the means of applying expert and up-to-date knowledge to the products which metallurgists and engineers together place at the service of the ultimate user.

Owing to the limited time available at the technical sessions a number of papers presented were not discussed, but considerable interest was shown in several papers. Here it is only possible to give brief summaries of the subjects presented.

A DEEP-DRAWING TEST FOR ALUMINIUM

Under the influence of the drawing tools a metal is subjected to deformation, first of all in compression and then in tension, so that its suitability, or otherwise, is determined by its properties in the plastic range. Few, if any, of the ordinary mechanical tests give much indication of the behaviour of a metal in this range, though from time to time attempts have been made to devise simple means for testing the suitability of metal for drawing or pressing. These may be divided into two classes: (1) the so-called cupping tests of which the Erichsen test may be taken as typical, and (2) the tests based on the deep-drawing process itself.

In this paper, by Dr. A. G. C. Gwyer and Mr. P. C. Varley, a new test for estimating the deep-drawing quality of aluminium is described. The authors' experience, in the case of aluminium, has shown that the test based on the cupping operation is not sufficiently sensitive to detect small differences in drawing properties, but that it is not necessary to employ elaborate pressure measuring devices. They state that the addition of a re-drawing operation increases the sensitivity of the test to a very large extent and, using only simple apparatus, which can readily be made, it is possible to detect, and to some extent to evaluate, the small difference in drawing properties resulting from variations in composition, temper, and previous history of the metal.

The authors give figures illustrating the application of the test to normal commercial purity metal in various tempers, and it would appear that, though the test is a simple one, it is capable of distinguishing small differences in drawing properties, differences that would not be suspected from a study of the mechanical properties of the materials. At the same time it furnishes much useful information as to the actual behaviour of the metal in deep-drawing.

THE TRANSFORMATION IN THE COPPER-GOLD ALLOY CU_3 AU

The alloys of copper and gold exhibit certain interesting solid transformations at compositions approximating to Cu_3 Au and Cu Au. Since the discovery of these transformations in 1916, a large number of experimental investigations have been carried out. Recently a number of theoretical papers have appeared which purport to explain the phenomena in a quantitative manner. Most of the experimental work hitherto carried out on order-disorder transformation has given results unsuitable for direct comparison with the theoretical work. In this paper, by Dr. C. Sykes and Mr. H. Evans, the effect of the transformation of the alloy Cu_3 Au on the electrical resistance, X-ray structure, and specific heat describe an experimental investigation, and it is shown that the general character of the transformation is satisfactorily predicted by the Bragg-Williams* theory of the formation of super-lattices by atomic rearrangement.

The atomic rearrangement process involves first the formation of small nuclei having a relatively high degree of order. These nuclei then grow to a size approximating to that of the individual crystals, if a constant temperature is maintained. If, however, the alloy is continuously cooled before it attains equilibrium, two processes proceed simultaneously, then nuclei tend to grow, and at the same time the degree of order in the nuclei increases owing to the reduction in the temperature.

The existence of such nuclei is not considered in the statical theory of super-lattices, so that it is not surprising to find that the theoretical predictions regarding the rate of relaxation into the equilibrium state are not in agreement with experiment.

THE EFFECT OF MOLTEN SOLDER ON SOME STRESSED MATERIALS

The rapid penetration and weakening of various tension-stressed materials by molten solder and other metals and alloys has often been observed in engineering workshops. Frequent breakages of high-tensile brass fittings whilst being soldered and screwed into position, and the

* W. L. Bragg and E. J. Williams, *Proc. Roy. Soc.*, 1934, [A], 145, 699.

unexpected fracture of a high-tensile alloy steel cylindrical shell led to this investigation by Mr. G. Wesley Austin. Solder was subsequently found on the fracture face of the steel cylindrical shell, and, as the operation of soldering is carried out extensively in engineering practice, an effort was made to determine, quantitatively if possible, the susceptibility of the commoner metals and alloys to the combined effects of stress and molten solder.

As a result of the investigation it is shown that almost all the usual metals, alloys and steels, employed in general engineering, if tensile stressed and in contact with molten solder, are susceptible to penetration and weakening to a greater or less degree. Nickel, Monel metal, and cupro-nickel are, however, but slightly affected. The plain low-carbon steels, and the lower carbon pearlitic and austenitic heat- and rust-resisting steels do not appear as subject to penetration as similar steels with higher carbon. The liability to penetration in the heat-treated alloy steels tested becomes greater with increasing hardness and secondary grain-size, especially the former. Neither the temper brittle nor the burnt state appears of itself to increase greatly the susceptibility to penetration of the alloy steel tested.

The phenomenon has been shown to be an interruption of the normal tensile deformation curve at a point depending on the material and conditions of the test. The shape of the curve thereto appears unaltered. The action is thus not dissimilar to that of discontinuities, notches, certain types of chemical attack, or the brittle state, and is probably due to intergranular penetration. The cohesion is reduced, whilst the resistance to deformation persists.

These conclusions the author suggests may be applied as follows :—

It appears advisable when soldering parts, especially if screwed, or of shape liable to stress concentration, to avoid the application of any load or temperature gradient which may give rise to tensile stresses at the surface in contact with the molten solder. The phenomenon may have application for the technological parting off, or destruction of such materials and parts as are readily surface-stressed and penetrable by molten solder. The increased deformability shown by aluminium, Duralumin, and Elektron, in the presence of molten solder, may present a possible means of facilitating the hot-forming of these materials. The method of investigation, if pursued, may throw light on the nature of technical cohesion and grain boundaries.

PLASTIC DEFORMATION AND AGE-HARDENING OF DURALUMIN

In this paper Major P. L. Teed describes an investigation on the influence of plastic deformation on the air temperature age-hardening of test-pieces from the same 16-gauge sheet of Duralumin, which were normalised at 490° C. for 30 minutes, cold-water quenched, and then plastically deformed to varying extents. It is shown that plastic deformation of the type employed in the experiments described, produces, with the freshly normalised, cold-water quenched alloy, an acceleration of the normal age-hardening process, a marked increase in the proof stresses ultimately developed by the material after prolonged subsequent storage at atmospheric temperature, a slight decrease in its ultimate stress, and a relatively greater decrease in its shear stress. Similar deformation of specimens from the same sheet, but fully age-hardened prior to deformation, gives rise to an immediate increase in hardness which is virtually stable and increases in the proof and ultimate stresses.

While the numerous determinations which are cited in this paper are not wholly free, in spite of many precautions, from certain anomalies, particularly as regards the hardness determinations recorded, the author submits that his conclusions have experimental justification. For the user of Duralumin for structural purposes, the results emphasise the desirability of carrying out plastic deformation subsequent to age-hardening, whenever this is possible, for the resulting mechanical properties of the alloy will be markedly superior to those obtained if this deformation precedes ageing. From the point of view of one attempting the by no means simple nor uncontentious task of constructing a wholly satisfactory theory of age-hardening, the experiments described are certainly not opposed to the thesis of precipitation from supersaturated solution, indeed, in the author's opinion, which he offers with a diffidence justified by experience, they may be regarded as giving support to this now generally accepted view.

EXPERIMENTS ON THE ELECTRICAL RESISTANCE OF COPPER AND SOME COPPER ALLOY WIRES

It is generally believed that when hard-drawn high conductivity copper is annealed at a temperature of about 500° C. the minimum value for electrical resistance is obtained. Up to 500° C. the sharp decrease to this minimum is due to the recovery of the metal from the work-hardened state, whilst the gradual increase in resistance on annealing at temperatures progressively higher than 500° C. is usually described as " over-annealing." Several years ago it was shown that for annealing temperatures above 500° C. the rate of cooling affected the resistance, slow cooling resulting in values either equal to or only slightly greater than those obtained on annealing at 500° C. In this investigation by Mr. Clement Blazey experiments were carried out to ascertain if this result applied to other brands, and if it could be influenced by variations in composition and in melting and working conditions.

For this purpose the electrical resistances of wires made from seven samples of H.C. wire-bar copper, two samples of cadmium-copper, a furnace-refined copper and various specially-prepared samples were measured after annealing in carbon dioxide over the range 300°–950° C. Two methods of cooling from the annealing temperature were used : quenching in water, and slow cooling in the furnace ; slow cooling was sometimes replaced by reheating at a fixed temperature, such as 500° C.

It was found that, in general, minimum resistance is obtained on annealing at about 500° C., and that a steady increase in resistance occurs when the wires are quenched from temperatures above 500° C. This increase, however, tends to disappear when slow cooling is adopted or when the quenched wires are reheated at 500° C. In wire-bar copper the increase due to quenching from 950° C. varies from about 0·5 to 1%. It is not greatly affected by variations in cold-drawing methods or by heat-treatment of the rolled rod before drawing. With cadmium-copper, quenching from a high temperature does not increase the resistance to an unusual degree, but with fire-refined copper it causes an increase of nearly 10%.

Wires drawn from wire-bar copper that has been remelted under charcoal show a greater increase in resistance on quenching from a high temperature than those made from the original wire-bars. When, however, the remelting takes place in conditions that permit an increase in oxygen content, the resulting wires show only slight differences in resistance with variations in annealing treatment. Additions of sulphur and selenium to copper of low-oxygen content cause marked increases in resistance on quenching from high temperatures. In these instances the slowly cooled samples contain numerous small inclusions, but the quenched samples are free from them.

The following causes for the increase in resistance on quenching from high temperature are briefly considered : (*a*) the nature of the furnace atmosphere (*b*) alterations in dimensions of the wires (*c*) quenching stresses (*d*) the presence of blowholes (*e*) chemical composition, and (*f*) grain structure.

THE PHYSICAL PROPERTIES AND ANNEALING CHARACTERISTICS OF STANDARD NICKEL SILVER ALLOYS

A great number of compositions can be produced which may be classed as nickel silvers, and in the absence of any official classification and standardisation there has, in

the past, been more than a tendency for a bewildering variety of compositions to be produced. To obtain some sort of order out of the prevailing chaos, a committee was appointed by the British Standards Institution to standardise these alloys having regard to the requirements of producers and consumers. The work of this committee is still in progress, but the compositions given in Table I. have been suggested as standard for wrought alloys, since, so far as can be ascertained, these alloys satisfactorily meet the requirements of the applications in which they are commonly employed.

The investigation in this paper by Dr. Maurice Cook was undertaken to obtain systematic data on the properties of alloys conforming to the requirements of composition specified by the B.S.I. Committee. A detailed study was made of the hardness and mechanical properties as affected by progressively increasing amounts of cold-work, and of the annealing characteristics of seven nickel silver alloys with a constant copper content and containing 10–30% nickel. The increase in hardness occurring on rolling reductions up to as much as 90% was determined for all seven alloys, and for the three alloys of highest, intermediate, and lowest nickel content the effect of cold-work on the mechanical properties was studied in detail. Similarly, the annealing characteristics were determined for all the alloys by means of hardness tests, whilst in the case of the three alloys already mentioned this information is supplemented by data on the mechanical properties.

The modulus of elasticity increases progressively with nickel content, and in the annealed condition the hardness also increases with the nickel content. This difference in hardness, however, is not maintained when the materials are cold-worked, and after a reduction of 90 per cent. in thickness by cold-rolling the order of hardness is reversed—*i.e.*, the highest value is obtained with the 10% nickel alloy and the lowest with the 30% nickel alloy. In other words, the extent to which the alloys can be work-hardened decreases with the nickel content.

The temperature at which softening commences on annealing increases with the nickel content. In common with other copper-rich alloys, the temperature at which softening commences in an alloy of given composition decreases with increasing amount of cold-work and the extent to which hardening occurs immediately prior to the commencement of softening also increases with the amount of cold-work.

Information is given on the density, electrical and thermal conductivity, and thermal expansion of the alloys.

A STUDY OF THE FATIGUE CHARACTERISTICS OF THREE ALUMINIUM SPECIMENS EACH CONTAINING FROM FOUR TO SIX LARGE CRYSTALS

A series* of previous papers contains the results of a study of the fatigue characteristics of single metallic crystals conforming to various representative space-lattice systems. One major conclusion, which emerged from this work was that the deformation and failure characteristics, under fatigue stressing, of metals in their simplest form, were controlled essentially by what was termed the "maximum resolved shear-stress law." The present paper by Dr. H. J. Gough and Mr. G. Forrest gives the results of a further study in which tests are made on specimens containing a larger number of crystals. In general the main objects of the experiments described were: (1) to study the effect of the crystal boundaries on the slip-band distribution, and (2) to study the position of fatigue-cracking in relation to the resolved shear-stress distribution and to crystal boundaries.

For this purpose three specimens of aluminium, each consisting of from four to six large crystals, were submitted to alternating torsional fatigue tests. Each specimen was tested at a constant range of applied torque throughout: two specimens fractured, one remained unbroken. The observed changes in microstructure were related to the crystalline structure—as revealed by X-rays—and to the applied stressing system, particular attention being given to the influence of the intercrystalline boundaries on the deformation and fatigue-resistance.

It was found that the slip-band distribution of each specimen obeyed very closely the maximum resolved shear-stress law, calculated for each crystal as if it alone occupied the entire specimen: the influence of the boundaries on the slip-band distribution was extremely slight. Cracking occurred in regions subjected to high values of resolved shear stress. These regions were often situated in close proximity to a boundary, but the results indicate that the influence of boundaries, as such, on fatigue-cracking is very slight. In fact, it has been clearly established that fatigue-cracking is not initiated at the boundary, and also that the general course of a crack does not tend to follow a boundary.

The fatigue histories of the specimens reveal a fatigue limit, on an endurance basis of 10^8 stress cycles, of about $\pm 1 \cdot 0$ ton/in.^{2} resolved shear stress, which differs but little from that of single crystals of aluminium

* For critical and descriptive summary, see H. J. Gough, "Crystalline Structure in Relation to Failure of Metals—Especially by Fatigue," *Proc. Amer. Soc. Test. Mat.*, 1933, 33, (II), 3.

THE MAGNESIUM-COPPER ALLOYS, PART V—THE COPPER-RICH ALLOYS

This paper, by Professor W. R. D. Jones, is part of a comprehensive study of the magnesium-copper alloys, and is concerned with copper-rich alloys containing magnesium up to 6%. Owing to the great affinity of magnesium for gases, considerable difficulty has been experienced in producing sound ingots of these alloys. Unless the molten copper be free from gas and oxides before the magnesium is added, a large amount of dross is formed which is difficult to disentangle from the metal.

The author states that the effect of magnesium on copper is beneficial up to an addition of about 2%, but the alloys do not offer much hope of being useful in view of the great difficulty of obtaining good castings and the fact that many copper-rich alloys with other metals, such as zinc, tin, and nickel, have better mechanical properties which can be obtained with much less trouble.

AN ELECTROLYTIC TEST FOR ZINC COATINGS ON WIRE

In view of the shortcomings of such tests as the Preece test, a research on the subject of the testing of zinc coatings was carried out for the British Non-Ferrous Metals Research Association and the electrolytic-test described in this paper by Mr. S. C. Britton was developed. Two tests are proposed: A stripping test designed to estimate the weight of coating which must be removed by uniform attack before the iron base is exposed, and a wrapping treatment followed by a stripping test designed to gauge the liability of a coating to crack. The stripping test is carried out by electrolysis in a specially designed cell, a fixed current density being employed so that each unit of testing time corresponds to a known weight of coating; at the end of the test, a short dip in copper sulphate solution serves to show whether the iron base has been exposed. The test is primarily intended to ascertain whether a coating meets a specification but can be used to determine the actual thickness of coatings. Potential measurements made during strippings provide information as to the structure of coatings. Thus, it has been shown that close-wiped coatings and galvannealed coatings consist almost entirely of zinc-iron alloy. Field tests are demonstrating that the test described gives satisfactory results for conditions of atmospheric exposure while the Preece test has marked shortcomings.

THE CONSTITUTION OF THE TIN-RICH ANTIMONY-TIN ALLOYS

The system antimony-tin has been studied by many investigators who are in general agreement that the liquidus consists of three branches corresponding to the

separation of three solid solutions, though their results differ considerably in detail. All these workers give the solubility of antimony in tin as 8–10%, but none of them carried out a detailed investigation of this part of the system. The most recent investigation of the whole system was carried out by Iwasé, Aoki, and Osawa. They found that the peritectic reaction SbSn + liquid → α occurs at 246° C., and that the solubility of antimony in tin at 220° C. is 8%. They considered that the transition at 320°–325° C. is a polymorphic transformation in the β (SbSn) phase.

In this paper by Professor D. Hanson and Mr. W. T. Pell-Walpole is described an investigation, by means of thermal analysis, microscopical examination, and electrical resistivity measurements, on the constitution of the tin-rich alloys of the system antimony-tin. It is shown that the liquidus had solidus of the tin-rich phase and the temperature of the peritectic reaction are in general agreement with the results obtained by Iwasé, Aoki and Osawa. The solubility of antimony in tin is shown to decrease from 10·5% at 246° C. to 3·5% at 100° C.

THE INFLUENCE OF LIGHT ON ELECTRODE POTENTIAL AND CORROSION PHENOMENA OF CERTAIN NON-FERROUS METALS

The investigation described in this paper by Prof. C. O. Bannister and Dr. R. Rigby was undertaken as a result of certain irregular effects obtained during some simple experiments on the influence of oxygen on metals in acid solutions, the only apparent explanation of which was to be found in the observation to correspond with periods of maximum illumination. The authors review previous work on the effect of light on the corrosion of non-ferrous metals, and describe a simple apparatus for the examination of the effects of light on zinc, lead, etc., under corroding conditions in conjunction with which a continuous record of changes in e.m.f. is made by the use of a thread recorder.

The influence is shown to be considerable in the case of lead and zinc, but only in the presence of oxygen, the aerated and illuminated electrode becoming more markedly cathodic. A more elaborate apparatus is then described arranged to allow perfect control over the oxygen supply to the metals under examination, and very marked response to illumination is shown in the case of zinc and aluminium. In the case of the latter metal, records showing activity over five days are given. The maximum effect is obtained with light in the violet and near ultra-violet region, and the mechanism of the action suggested is the catalysis of the formation of protective oxide films.

INFLUENCE OF SURFACE CUPROUS OXIDE INCLUSIONS ON THE POROSITY OF HOT-TINNED COATINGS ON COPPER

When copper is tinned by immersion in molten tin there are, in general, two types of coating that can be obtained. In the first the copper emerges from the tin coated with a smooth layer of molten tin which remains in place as such until it solidifies, forming a coating which, depending on the conditions of solidification, may either be smooth and bright, or may exhibit typical crystal boundaries or striations. In the second type, less tin remains on the copper, and may be either accumulated as ridges or isolated globules, the remainder of the surface in each case being very thinly covered. Since the second, or irregular, coating is liable to occur in commercial tinning practice, it is a matter of considerable importance to understand the conditions which give rise to it. In the investigation described in this paper by Dr. W. D. Jones, consideration has been given only to the degree in which the quality of the basis metal influences the formation of either type of coating.

This study of the causes of porosity of tin coatings on copper shows inclusions of cuprous oxide to be one of the most important. Amalgamation is suggested as a rapid means of estimating probable porosity. Various methods for reducing porosity are discussed: these include cathodic treatment in caustic-soda solution, and treatment with hypophosphorous acid. Oxygen-free copper is recommended as the best material to employ if non-porous coatings are to be obtained.

THE HOT-TINNING OF COPPER: THE ATTACK ON THE BASIS METAL AND ITS EFFECTS

Although the tinning of copper by hot-dipping has been carried out industrially on a large scale for many years, there appears to be a lack of data which fully explain the mechanism of the process, particularly with respect to the composition of the coating. It is well known that copper derived from the basis metal is invariably present in this coating, and there is abundant evidence that this copper affects the technique of the hot-tinning process. The investigation described in this paper by Mr. E. J. Daniels was carried out to discover the method by which the copper enters the tin, the degree of contamination obtained, and its effect on the nature of the coating obtained.

The author shows that the compound layer is invariably duplex, consisting of Cu_3Sn and Cu_6Sn_5. This layer breaks up under solvent attack, and is removed from the basis metal almost as fast as it is formed. Contamination of the bath and coating owing to this action increases rapidly with increase in temperature, and causes important effects on the smoothness of tin coatings to an extent that is influenced by the degree of the contamination and the quality of the basis metal.

New Electrode for Welding Bronze, Brass and Copper

Possessing Characteristics of Phosphor Bronze

A phosphor-bronze arc-welding electrode has been developed by The Lincoln Electric Company, Cleveland. This new electrode, which is called Aerisweld, is stated to be the result of many years of research and experiment. It has been thoroughly tested in the practical welding of bronze, brass and copper in many applications, and it is claimed to provide a solid homogeneous deposit, having characteristics of true phosphor bronze with notably high tensile strength.

The high-quality weld metal produced by the electrode makes it ideal for fabricating new products or reclaiming old ones of bronze, brass or copper. A few of the many applications for "Aerisweld" include: Busbars, large contacts, impeller blades in pumps and turbines, ornamental bronze, bronze doors, etc. Many types of bronzes which are exceedingly difficult to braze, are readily welded. The electrode is also valuable for welding galvanized sheets where minimum disturbance of the galvanizing is essential.

In reclamation of worn parts of equipment, this electrode is used to build up and fill in bronze castings, such as journal boxes and containers, for building up bronze valve seats, bronze-bearing surfaces on steel or cast iron, numerous guides, etc. It is a shielded arc electrode, for use with the metallic arc. Its coating, as it burns, produces a gas which shields the molten metal from harmful effects of the atmosphere and assists in easing the flow of molten metal in the arc.

In using this electrode the makers state that welding current of positive polarity is employed on the electrode. Pre-heating of the parts is unnecessary when welding any ferrous metal and the lighter grades of copper and bronze. Where heavy bronze or copper is to be welded, some pre-heating may be desirable due to the high heat conductivity of these metals. In such cases, pre-heating is easily accomplished by using a carbon electrode with the negative polarity and rapidly moving the arc over the area to be welded. For cast iron, low current is used, since excessive heat is detrimental to satisfactory welding of this metal.

"Aerisweld" electrode is made in two sizes, $\frac{5}{32}$ in. and $\frac{3}{16}$ in., 14-in. lengths and is packed in standard containers of 5 lb. net each size.

Length Variation of Steel Wire During Ageing following Severe Disturbance

By H. GOULBOURNE JONES, M.Sc., A.Inst.P.

Work conducted on the ageing of steel wire is discussed. The length variations during ageing were measured with an optical lever after quenching, magnetic disturbance and longitudinal stress. The curves show rather astonishing results, when the time-scale is considered.

THE length variations of a steel wire (·06 C, ·48 Mn) have been examined with an optical lever[1] after the steel has suffered various severe disturbances, observations being taken more or less continuously for a number of days. The wire has a diameter of 0·22 in., a length of 3·0 in., and its length is compared with a steel cylinder 3·0 in. high. In the first type of disturbance, the wire was annealed for about 20 mins. in an electrically-controlled furnace at 775 ± 5° C., quenched into cold water, and rapidly inserted in the comparison apparatus. Fig. 1 shows the variations obtained for the same specimen on two occasions, A and B, 14 days apart. There is a marked resemblance between A and B on Fig. 1, and the length of variations of nickel after quenching[2] in that a relatively large decrease in length occurs during the first 25 min., followed by little change up to $2\frac{1}{4}$ hrs. Although

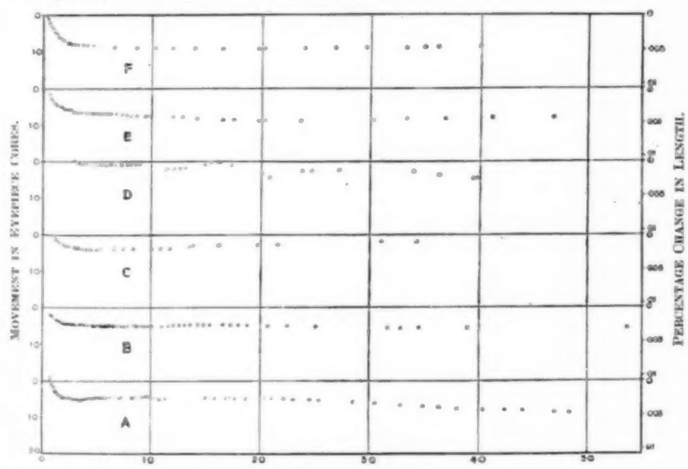


Fig. 1.—Steel strained by :
A. Quenching from 775° C. after 20 mins. annealing.
B. Quenching from 776° C. after 21 mins. annealing.
C. Quenching from 925° C. after 23 mins. annealing.
D. Alternating magnetic field.
E. Longitudinal stress for 15 hrs.
F. Longitudinal stress for 5 hrs.

the steel wire is compared with a steel cylinder, differences of 1° C. in the temperature of the surroundings require a correction of 0·1 cm. in the eyepiece reading—this correction has been applied to all the curves quoted in this paper. The minimum change that can be detected by the optical lever is $3\cdot6 \times 10^{-6}$ in., that is, roughly one part in a million in the length of the specimen.

Observations were continued for A and B over a long period of time resulting in a very small time-scale for Fig. 2. The sudden rise in B at five days will be discussed later, and apart from this rise, the two curves can be considered to agree well, including a minimum at one day and a maximum around three days. Curve A shows evidence of further fluctuations of a long but decreasing periodicity and decreasing amplitude. Also on Fig. 2 is plotted (for curve A) the temperature of the surroundings which has a day-to-day ripple, but has no similarity in shape with curve A itself. Each point shown is the mean of several readings, and so it appears that a real effect is being measured.

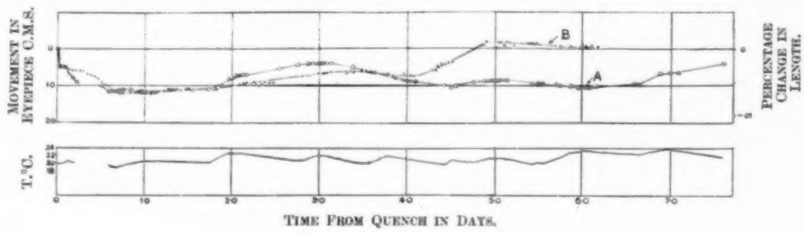


Fig. 2.—Cases A and B continued

In addition to the gradual changes discussed above, both A and B have large and sudden changes in form—A at seven days, B at $4\frac{1}{2}$ days —after which B resumes its previous mode of variation. These sudden changes were at first deemed due to some extraneous cause, such as magnetic fields or perhaps some unknown and uncompensated temperature effect, so the specimen and the metal parts of the optical lever have been surrounded by a shield consisting of $\frac{3}{4}$-in. wood backed with $\frac{1}{16}$-in. soft iron, and lined with $\frac{3}{8}$-in. asbestos.[3] Light is admitted through a 3 in. × 4 in. glass window $\frac{1}{16}$ in. thick. Rubber tiles were also placed under the legs of the bench, and in this way outside disturbances were minimised.

Some six weeks after case B, the same specimen was disturbed once more (case C) by annealing and quenching, but during the 23 mins. annealing the thermo-couple junction giving the annealing temperature burnt out, and so that temperature could only be estimated as being between 900 and 950° C. The curve C (Figs. 1 and 3) obtained on this occasion shows an immediate difference from A and B in that it starts rising after one hour, giving a gentle ripple for two days. Temperature variations still occur, but are less than ± 1° C for 24 hrs., and compensation is therefore

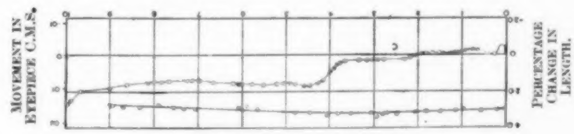


Fig. 3.—Case C, quenched from 925° C. after 23 mins. annealing.

easily applied. Curve C shows a big rise at $4\frac{1}{2}$ days, and a further rise at ten days, both of which are comparable to the rises in curves A and B (exact agreement is not

[1] *Journal Sci. Instr.*, p. 325. Oct., 1934.
[2] *Metallurgia*. July, 1935.
[3] Compare *Metallurgia*. Sept., 1934.

anticipated, because of the difference in annealing temperatures). Since the large changes occur also in curve C when the specimen is shielded, these changes cannot be attributed to stray magnetic or electrostatic fields, and check experiments reveal that neither can they be traced to mechanical disturbance. Thus, it would appear that these sudden increases in length are the major changes during the ageing of this steel wire after quenching. The table gives an analysis of these major changes in the curves A, B and C, from which it will be seen that after the early fall there is a rough cycle of a very slow nature having a period of about six days. The total amplitude of the change is very small, being less than 0·02% of the length of the steel. In Fig. 3 is also shown a check curve for the steel wire which had been left unstrained for 3½ months. The zero will thus be seen to be very steady, the slight drift from its mean position in nine days being only ± ·001% of the length of the specimen.

The second type of disturbance was applied to the same steel specimen seven weeks after the last of the heat strains, by placing it for 2 mins. in the ¼-in. gap between the pole-pieces of a large electromagnet actuated by A.C. at 50 cycles off the mains. The field was at right angles to the length of the specimen which was moved continuously so that all parts of its length came, in turn, under the action of the field. After this treatment the specimen was still unmagnetised, and was placed in the comparison apparatus as quickly as possible. The first reading recorded is shown on curve D, Fig. 1, at 18 min.; prior to this, the length variations were so uncertain as to hinder focussing of the optical system. At the 22 mins. mark the specimen settles down, but is still more unstable than after the heat strains. The instability lasts for 4 hrs., only to be followed by a relatively large decrease in length (Fig. 5) continuing, until 31 hrs. after the magnetic disturbance. For the next four days very little change takes place, and, on testing, the specimen was found to be still unmagnetised.

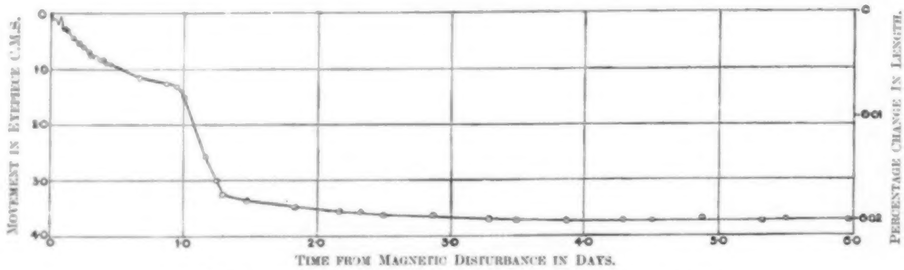


Fig. 5.—Strained for 2 mins. in alternating magnetic field.

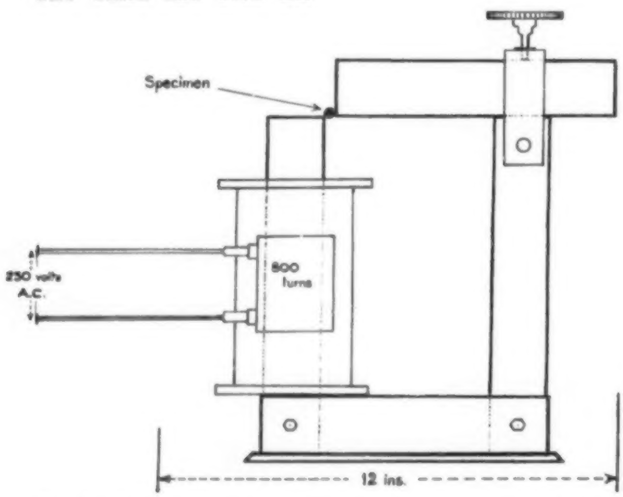


Fig. 4.—Showing the method of applying the magnetic disturbance. (The pole-pieces are laminated iron, 1½ in. × 1½ in.)

The curve on Fig. 5 indicates that after severe disturbance in a magnetic field, the steel is at first unstable, but after a day and a half settles down to a normal state with no trace of periodicity; this may be due to the closing of the chains of molecular magnets which, after the disturbance, would be in random directions, but unlinked. The length changes are certainly very different from the periodic hardness changes taking place in steel after magnetic disturbance.[4]

The third class of disturbance was applied to the same steel specimen by a longitudinal stress equivalent to 370 lb. weight per square inch. The load was hung from the specimens for 15 hrs., then the stress was removed, and the steel placed once more in the comparison apparatus. The first reading was obtained 4 mins. after the stress had been removed, and naturally most of the strain had disappeared from the material, but even so, a trace is found of the rapid decrease in length, as will be seen in curve E, Fig. 1, the early variations being larger than after the other disturbances. A minimum is found at 2½ hrs., and, on closing the time scale for Fig. 6 this minimum appears more pronounced. Fig. 6 also reveals the first evidence for this steel of a quick periodic change in length, followed, after the first cycle has died down, by the remarkable feature of unchanging length from 10 hrs. to five days. On repeating by straining the steel with the same load for 5 hrs., the result (curve F) confirms the above statement. Only a slight difference is found in the readings for E and F during early times after the disturbance, and this may be accounted for by the difference in the time the load was hanging on the steel.

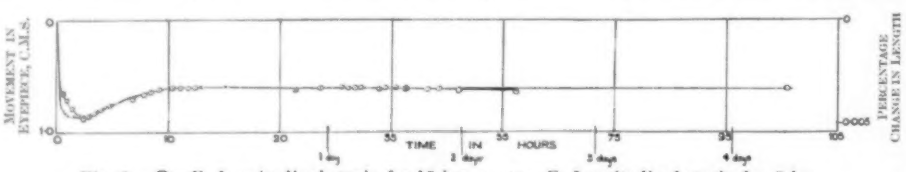


Fig. 6.—O—E, Longitudinal strain for 15 hrs.; ×—F, Longitudinal strain for 5 hrs.

Curve.	Date begun.	Temperature of soaking.	Large fall up to	Time from Quench in Days.			
				Min.	Max.	Min.	Max.
A	July 6	775° C.	22 min.	1	3	6	8+
B	July 20	776° C.	28 min.	1	5	6	—
C	Sept. 2	925° C.	23 min.	flat	4½	7	10
			Average ...	1	4	6½	10
				← 5½ days →			
					← 6 days →		

The longitudinal strain set up is not so severe as the previous strains, and this would be sufficient to account for simpler length changes during ageing, but, in addition, the internal mechanism of a longitudinal strain is probably more simple in nature than the complex change following quenching. The length variations in the latter case do not appear to correspond to changes in hardness, and at this stage no attempt is made to attach a physical meaning to the approximate cycle of six days. It is suggested, however, that all the curves quoted indicate remarkable evidence of small length changes during ageing after various types of severe strain.

[4] *Journal Iron and Steel Institute*, No. 1, p. 283, 1934.

Some of the decrease shown on all the curves for the first 20 mins. may possibly be accounted for by temperature changes following the rapid handling necessary during insertion into the comparison apparatus ; on the other hand, temperature changes after quenching into tap-water should give a movement in the opposite direction ; moreover, in E and F the handling was less than 30 secs. In the main, then, the rapid decrease during the first 20 mins. can be attributed to ageing.

I am indebted to Mr. E. G. Herbert, of Manchester, for supplying the steel wire, and for suggestions from time to time.

Metallic Wear

Some of the maj actors involved in metallic wear in the presence of lubricants were reviewed by Dr. H. W. Brownsdon, at a special meeting of the Institute of Metals, on March 10, and a method by which they can be quantitatively assessed was described.

THE conditions necessary for the measurement of wear between two metals are simple in principle, and can be brought about by causing the periphery of a moving wheel of one metal to come in frictional contact with a flat sample of another metal under known conditions of dimensions and speed of wheel, load, lubrication, temperature, and time. If these conditions can be fulfilled, the dimension of the impression made on the flat sample may be taken as a measure of wear. There is nothing new in this idea, and much experimental work has been done on similar lines, but the experimental conditions have generally been somewhat cumbersome, complicated, and unsuitable for obtaining quick results.

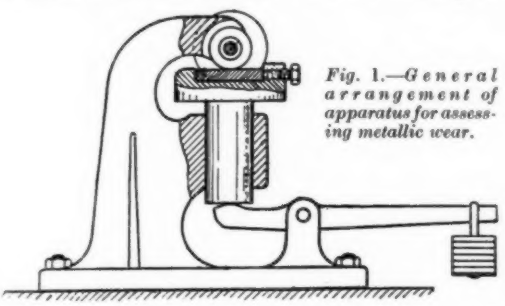


Fig. 1.—General arrangement of apparatus for assessing metallic wear.

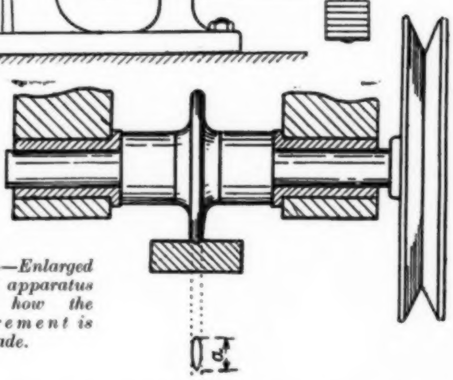


Fig. 2.—Enlarged detail of apparatus showing how the measurement is made.

The conditions of simplicity of apparatus, coupled with accuracy of measurement and the obtaining of quick results, are met by a machine designed on the lines shown in Figs. 1 and 2. Rapid working and accuracy of measurement are facilitated by giving the periphery of the wheel a suitable radius, for if this be flat, the stationary sample must also be perfectly flat and adjusted parallel to the flat face of the wheel. The measurement of the relatively long major axis of an oval impression made by a radiused wheel provides a much more open scale for detecting small differences.

In most of the experimental work to be referred to by Dr. Brownsdon, the wheel was of hardened steel (D.P. hardness 775), about 1 in. in diameter, 0.10 in. thick, the radius on the periphery being 0·05 in. The samples of metal tested were small flat plates about $\frac{1}{8}$ in. thick, 2 in. to 3 in. long, and $\frac{1}{2}$ in. to $\frac{3}{4}$ in. wide, these being fixed during testing by clamping to the face of the movable table through which the load is applied. The surface finish on both wheel and sample was that given by " 00 " emery paper, the wheel being polished after each test. All the tests were carried out under conditions of flooded lubrication, and at room temperature, generally at about 68° F.

Dr. Brownsdon's interest in the subject of metallic wear arose from a desire to study die-fouling problems associated with the drawing of hollow metal products in certain non-ferrous metals, where pressures are heavy and speeds high. Experimenting on the actual drawing plant was slow and inconvenient, and some means for making rapid comparative experiments under controlled conditions in the laboratory appeared to be the only means to investigate satisfactorily the problems involved ; by the aid of the machine referred to much useful information of direct bearing on the causes and prevention of die-fouling were obtained. The adhesion of the non-ferrous metal being drawn to the working surface of the steel die is akin to seizing in a bearing, and the effect of load, speed, lubrication, temperature, nature of the non-ferrous metal and that of the steel of the die, as well as surface smoothness of the die, all play some part in the phenomenon.

Experiments have been conducted on both ferrous and non-ferrous metals, and the results show the influence of several factors on metallic wear. It is pointed out that any attempt to picture the relative importance of the many variable factors is difficult, and the main value of this contribution may lie perhaps in bringing a number of these factors to a clearer focus. Comparative experiments made on the machine described clearly indicate the relative importance of the many conditions governing wear and should help in the choice of those most favourable to minimum wear. With such a large number of variable factors it is impossible to give more than a bare outline of their relative bearing on wear problems. No attempt has been made to give reasons for the causes giving rise to some of the observations made, but it may be anticipated that the finding of satisfactory explanations will be facilitated by extended experimental work in the directions indicated in this paper.

Dr. Brownsdon concludes with a note of warning against drawing wide and general conclusions from some of the observations recorded in this paper, for these are based on specified materials and conditions of experiment, and should not be taken for granted as applying to other materials and conditions. Wear is the resultant effect of so many variables that unless these be very closely defined conclusions drawn from experimental work may easily be misleading.

Lead Production in Canada, 1935

Canada's lead output last year totalled 337,459,472 lb., or slightly less than the 1934 total of 346,275,576 lb., but the estimated value is up from $8,436,658 to $10,620,000, or 26% higher.

The Sullivan mine in British Columbia, owned and operated by the Consolidated Mining and Smelting Co., Ltd., is the source of the major part of the Canadian lead output. Lead is also contained in the ores of the Britannia and Premier mines, which are exported for treatment. The Monarch mine at Field, B.C., ceased production towards the close of the year and will concentrate on development work. The Mayo camp in the Yukon was responsible for the production of 114,693 lb., and the Tetreault property in Quebec began production in June after having been shut down for several years.

Methods of Analysis for Impurities in Copper and Brass*

IT is not possible to standardise methods of analysis for the determination of small amounts of particular impurities in every raw material or alloy. It is possible, however, to give broad principles of procedure, which, with suitable modifications in regard to detail, can be adopted over wide ranges.

The accurate determination of small amounts of impurities is dependent, in most cases, upon their complete isolation from the main constituent, followed by subsequent gravimetric, volumetric or colorimetric estimation. The choice of the precise method must be governed by the amount and reactions of any particular element, and in all such procedure it is of the utmost importance that a blank analysis of the reagents should be carried through simultaneously with the determination.

There are certain cases in which precipitation of elements can be effected completely in the presence of the major constituents in solution; noticeable among these are the determinations of silver, iron, sulphur and phosphorus. Silver chloride is sufficiently insoluble in nitric acid to allow its precipitation to be a general feature in the analysis of copper and brass, and even when the quantity of precipitate is so small that gravimetric procedures are inadmissible, turbidemetric methods can be adopted. Sulphur as barium sulphate and phosphorus as ammonium-phospho-molybdate can be precipitated in the presence of the major constituents, but in the gravimetric determination of these elements the necessary precautions to ensure complete oxidation during solution, in each case, are often overlooked, and low results consequently obtained.

In the case of sulphur determination, complete oxidation can be obtained by dissolving the sample in a large excess of nitric acid, or better still, by dissolution of the sample in a mixture of a saturated solution of potassium chlorate and bromine, and subsequent treatment with hydrochloric acid. In the determination of phosphorus over ·04% to ·05% complete oxidation is obtained by adding a few mls. of a strong solution of potassium permanganate to the solution obtained after treatment of the sample with nitric acid. In this procedure, when conditions for dissolution and precipitation are standardised concordant results are obtained independent of the method of estimating the precipitated phosphorus, that is whether it is weighed as ammonium-phospho-molybdate, reprecipitated, and weighed as lead molybdate or as manganese pyrophosphate, or whether the phosphorus equivalent of the precipitate is determined by volumetric means. On the other hand, in the presence of the major constituent, the determination of small amounts of lead, as lead sulphate, and of selenium or tellurium is not satisfactory. In the case of lead, the solubility of its sulphate in the large volume of liquid required to hold the copper salts in solution is sufficiently high to render the determination inaccurate. Again, in the case of selenium and tellurium, the direct precipitation of these elements by the continual passage of the sulphur dioxide gas through a nitric sulphuric-acid solution of the sample as recommended in certain text books is open to criticism, on account of the tendency for the formation of copper selenide and the incomplete precipitation of tellurium, due to the presence of nitric acid.

The use of carriers or collectors for aiding precipitation and carrying down of impurities offers a means whereby small amounts of certain impurities can be separated from their main constituent, but the choice of suitable absorbants has been, and probably will be, a matter of controversy among analytical chemists. As an example of this principle, the addition of a soluble salt of copper to a solution containing a trace of lead, followed by saturation with sulphuretted hydrogen may be quoted. This treatment will cause the complete removal of lead from the solution. Again, iron in sufficient quantity, when thrown out of solution as ferric hydroxide, will carry down small amounts of lead, bismuth, arsenic, antimony, tin, selenium, and/or tellurium. The addition of potassium bromide and potassium permanganate to a nitric acid solution of copper, results in the precipitation of manganese dioxide, in which is occluded any tin, antimony and/or bismuth present in the sample.

Electrolytic deposition offers another means of separating certain elements, and now that the conditions are more closely defined, the electrolytic separation of lead as peroxide is rapidly finding favour, particularly as a preliminary operation for the determination of traces. This method of separating small amounts of lead from copper or brass is very neat in technique, and exceedingly accurate, if the final determination is carried out by colorimetric procedure. The advantages of such a method are that a small weight of sample can be taken, and in addition, precipitation and filtering operations are not encountered in the preliminary separations. The separation of aluminium can be effected by an electrolytic procedure, using mercury as a cathode, whereby copper, zinc, iron, nickel, tin, bismuth are deposited from a sulphuric acid solution, leaving aluminium and magnesium in the electrolyte.

Distillation as a means of separating arsenic, and occasionally antimony from copper or brass, is adopted in several works' laboratories, but the method is which these principles can be applied to the determination of sulphur is, perhaps, not so well known. The determination of sulphur in copper, copper-tin, copper-zinc, copper-nickel and copper-nickel-zinc alloys can be achieved by dissolving the sample in hydrobromic acid in an apparatus of the "Schulte-Franke" type. The sulphur present as sulphide is distilled off as hydrogen sulphide gas, carried over in a stream of an inert gas, such as carbon dioxide or nitrogen, absorbed in cadmium acetate solution, and the sulphur equivalent of the precipitated cadmium sulphide determined by volumetric means. This procedure is rapid, comparatively simple in manipulation, less affected by errors in technique than any gravimetric method, since it does not depend upon an oxidation process for its accuracy, and, in addition, as the determination is carried out in a totally-enclosed apparatus, contamination by sulphur-bearing atmospheres is eliminated.

*Extract from paper by F. T. Longman, before Midland Metallurgical Societies, March 5, 1936.

Nickel-clad Steel Plate

(*Continued from page* 140.)

Nickel flux-coated electrodes are used. Bare wire and wire improperly coated are unsatisfactory. A short arc—$\frac{1}{16}$ in. to $\frac{1}{8}$ in. long—is an absolute necessity. The efficiency of the flux in protecting the molten metal is seriously lowered if it is transferred through a long, arc stream.

The size of the electrode must be carefully considered, and the welding current must balance the penetration and the rate of electrode fusion. The thickness of the plate must also be considered in this connection, and the amperage used may vary slightly from that employed in steel-welding practice.

Plate Thickness.	Weld Rod Diameter.	Amperage.
$\frac{3}{16}$—$\frac{1}{4}$ in.	$\frac{1}{8}$ in.	90—150
$\frac{3}{16}$—$\frac{3}{8}$ in.	$\frac{5}{32}$ in.	140—160
$\frac{3}{8}$—$\frac{1}{2}$ in.	$\frac{5}{32}$ in.	160—190
$\frac{1}{2}$ in. and heavier	$\frac{3}{16}$ in.	180—225

It is recommended in the welding of the nickel side that the work should be negative.

In welding by the oxy-acetylene process, as in the case of metallic arc welding, the steel weld is laid down first employing the usual methods in common use for this metal. In welding the nickel side the flame should be maintained so that it is slightly reducing. This is important, in order to prevent brittleness in the weld. A tip one size larger than the tip used for steel under similar conditions has been found to be satisfactory. A flux can be used if preferred, but it is not essential.

Thermal Conductivities of Metals and Alloys

By J. W. DONALDSON, D.Sc.

In a previous article which appeared in METALLURGIA, *the author reviewed the work which had been carried out on the thermal and electrical conductivities of both ferrous and non-ferrous metals and alloys. It was concluded that the data obtained for such conductivities showed that the Lorenz law $K\sigma = T$ constant; where K is the thermal conductivity, σ the electrical resistivity, and T the absolute temperature ; held for pure metals, and also held with a considerable degree of accuracy for alloys, such as steel and the alloys of copper and of aluminium, but due to the complex nature of cast iron, such a relationship wasd ifficult to establish for the latter material. During the last eighteen months, further work has been published dealing with the thermal and electrical conductivities of metals and alloys, particularly with thermal conductivity, and it is now proposed to consider such work.*

THE thermal and electrical conductivities of iron, tungsten, molybdenum, and silver were determined by Kannuluik[1] over a temperature range from − 180° C. to 100° C. The metals used were extremely pure, the iron being of 99·88% purity, and the tungsten was in the form of single crystals. Measurements were made on a metal wire by an electrical method at 100°, 0° − 78·5°, and − 180° C. The values for electrical resistivity, thermal conductivity, and the Lorenz function at 0° C. are given in Table I. The values obtained for the Lorenz coefficient of iron, molybdenum, and silver agree with those obtained by other investigators for such metals as aluminium, copper, magnesium, nickel, and zinc ; but that obtained for tungsten is decidedly higher. As the temperature was raised to 100° C., a slight increase in the Lorenz coefficient of these metals was obtained similar to that observed to take place with aluminium and nickel. With a decrease in temperature, however, the Lorenz coefficient for the four metals decreased rapidly, 2·11 and 1·60 being obtained for iron at − 78·5° and − 180° C. respectively, and somewhat similar values for molybdenum and silver. Those obtained for tungsten were slightly higher.

The thermal conductivity of high purity nickel, commercial nickel, and high purity zinc has also determined over a range of temperature from 0° C. to 600° C. by Van Dusen and Shelton.[2] These investigators did not measure the thermal conductivity directly, but employed a method whereby they compared the conductivity of a metal, either directly or indirectly with that of pure lead, the conductivity of which was fairly well established. Determinations were made by measuring the axial temperature gradient in two cylindrical bars, soldered together end to end, one end of the system being heated and the other end cooled, and the convex surfaces being protected from heat losses by a surrounding guard tube. The conductivity values obtained for zinc showed a slight decrease with increasing temperature up to 300° C., and in this respect are in agreement with those of Schofield. They are, however, about 6% higher in value than those obtained by Schofield[3], but the authors consider this to be of little significance, as the conductivity of high purity zinc is stated to vary with its method of preparation. The values obtained for nickel show a minimum at 400° C., and as regards the commercial nickel approximate to the values obtained by Schofield. The high purity nickel, however, has a conductivity some 20 to 25% higher than the commercial nickel.

TABLE I.

THERMAL AND ELECTRICAL CONDUCTIVITIES (KANNULUIK).

Metal.	Temp. °C.	K.	σ	Kσ/T × 10.
Iron	0	0·1688	9·57	2·47
Tungsten ..	0	0·399	4·98	3·04
Molybdenum	0	0·329	5·17	2·61
Silver	0	0·999	1·510	2·31

Copper Alloys

The thermal and electrical conductivities at 20° C. and 200° C. have been determined by Smith and Palmer [3a] for the binary alloys of copper with silicon, aluminium, manganese, and nickel, and for a large number of ternary and more complex commercial alloys. In the binary, it was found, that as the amount of the added element increases in the solid solution range, the conductivities decrease, and the Lorenz ratio increases, at first rapidly, and then more slowly. The thermal conductivity of all the alloys increased with temperature, although that of pure copper decreased.

The ratio between the thermal and electrical conductivity was found to vary considerably, but it was shown that all the results at both temperatures for all copper alloys be on a single curve obtained by plotting the thermal conductivity against the product of the electrical conductivity and the absolute temperature. This curve is almost a straight line, and intersects the thermal conductivity axis at a small but definite value, and the results of all the alloys measured lie much closer to this curve than to any other curve of constant Lorenz ratio. It is suggested that alloy of metals other than copper probably lie on similar curves.

Nickel-Chromium Alloys

Thermal conductivity determinations were also made by the same investigators on an alloy containing 95% nickel, 2% aluminium, 2% manganese, and 1% silicon ; two nickel-chromium alloys containing 90 and 80% of nickel and 10 and 20% of chromium ; and two nickel-chromium-iron alloys with 61 and 34% of nickel, 16 and 10% of chromium, and 23 and 56% of iron. The thermal conductivity of the first alloy was 0·071 cals. at 100° C. The 90 : 10 nickel-chromium alloy had a thermal conductivity at 100° C. approximating to 0·046, and the 80 : 20 alloy a value of 0·033 at the same temperature. The values obtained for the two nickel-chromium-iron alloys approximated to the 80 : 20 alloy, and all the five alloys showed an increase in thermal conductivity with increase in temperature to the extent of about 30% at 400° C.

Alloy and Stainless Steels

The thermal conductivities over the temperature range 100° C. to 500° C. were determined by Shelton[4] for 20 irons and steels which were selected as typical examples of commercial materials used for a variety of purposes. These included a low-nickel steel, 1·37% nickel ; a low-manganese steel, 1·65% manganese ; a low-tungsten steel, 1·04% tungsten ; a low chromium steel, 5·15% chromium ; a manganese-nickel steel, 12 to 13% manganese, 3% nickel ; a chromium-aluminium steel, 17·12% chromium, 1·55% aluminium ; four chromium steels containing 12 to 26% chromium ; and five chromium-nickel steels of the 18 : 8 variety.

1 W. G. Kannuluik. Proc. Royal Soc., 1933, [A] Vol. 141, p. 159.
2 M. S. Van Dusen and S. M. Shelton. Bureau of Standards, *Journal of Research*, 19[illegible]. Vol. 12, p. 429.
3 F. W. Schofield. Proc. Royal Soc., 1925, [A] Vol. 107, p. 206.
3a. C. S. Smith and E. W. Palmer, Amer. Inst. Mining and Metallurgical Engs Technical Publication No. 648, 1935.
4 S. M. Shelton. Bureau of Standards, *Journal of Research*, 1934, Vol. 12, p. 441.

The results obtained indicated that, in general, the differences in the thermal conductivity of steels was much smaller at higher temperatures than at atmospheric temperatures, and that high alloy steels had much lower thermal conductivities than low alloy steels. The thermal conductivities of these alloy steels at 100° C. and 400° C. are given in Table II. The determinations which were made in watts per cem. per degree have been calculated to cal. per cem. per sec. for comparison with other results. The low alloy steels of nickel, manganese, tungsten, and chromium show a decrease in conductivity with increase in temperature, whereas the high alloy steels of chromium and chromium-nickel show an increased thermal conductivity with increase in temperature. Shelton considers this increase in thermal conductivity with increase in temperature to be due to the amount of the alloying constituents in iron, but he also considers it to be practically impossible to generalise on the quantitative relationship of thermalc onductivity and total alloy content of ferrous materials, due to the many and sometimes conflicting factors concerned. The data on the chromium and chromium-nickel steels are of particular interest, because of the lack of previous data on the thermal conductivity of the stainless steels.

TABLE II.
Thermal Conductivities of Alloy Steels (Shelton).

Material.		100° C.	400° C.
Low-nickel steel		0·107	0·094
Low-manganese steel		0·097	0·087
Tungsten steel		0·092	0·084
Low-chromium steel		0·088	0·082
Chromium steel	15·19% Cr.	0·063	0·063
Chromium steel	12·0% Cr.	0·060	0·066
Chromium steel	14·6% Cr.	0·058	0·061
High-chromium steel	26·0% Cr.	0·050	0·057
Chromium-aluminium steel		0·042	0·050
Manganese-nickel steel		0·035	0·044
Chromium-nickel steel	18·6% Cr. 9·1% Ni	0·039	0·049
Chromium-nickel steel	18·5% Cr 9·21% Ni	0·039	0·048
Chromium nickel steel	19·6% Cr 8·96% Ni	0·037	0·048
Chromium-nickel steel	19·6% Cr 7·99% Ni	0·036	0·047

Tool Steels

Results of a somewhat similar general nature were obtained by Hattori[5] on tool steels. Three carbon tool steels with carbon contents ranging from 0·93 to 1·41% carbon; an oil-hardening non-deforming steel containing 0·79% carbon, 0·645% chromium; a low-tungsten finishing steel containing 1·02% tungsten; and four high-speed tool steels containing 3 to 4% chromium and 15 to 19·3% tungsten. One of the latter steels contained 4·9% cobalt. Thermal conductivity determinations were made on these various steels in their annealed condition, after quenching, and after quenching and tempering at various temperatures.

These determinations show that the thermal conductivity of carbon tool steels has a tendency to decrease with increase in temperature, while the conductivity of special tool steels hardly changes with a temperature increase, and those of high-speed tool steels are increased. Thermal conductivity also varies with the structure of the steels, being highest with a pearlitic structure and decreasing as the structure changes to martenstite and then to austenite. In other words, a quenched carbon tool steel has a lower thermal conductivity than it has before quenching, a result which was also obtained by Shelton[4] with a 0·83% carbon steel. For the same reason, the higher the quenching temperature of carbon tool steels, the lower is their thermal conductivities. In quenched carbon tool steels and in the special tool steels containing chromium or tungsten, the thermal conductivity increases with the tempering temperature, the increase being more rapid at 250° C., and the conductivity approximating to the thermal conductivity in the annealed condition when tempered at 400° C. This is due to the change from austenite to martensite, and then to sorbite. It would appear that sorbite has a thermal conductivity similar to that of pearlite.

The conductivity of the high-speed steels decreases greatly after quenching, and on tempering it increases a little at 300° C., rapidly at 550°, and still more at 700° to 800° C. The greater durability, for heavy cutting, of high-speed tool steels, which are quenched and tempered at 550° C. to 600° C. would appear to owe much to their better thermal conductivity.

Cast Irons

In a series of determinations on the electrical and thermal conductivities of cast iron by Söhnchen[6], it was found that by increasing the proportion of graphite to total carbon, the electrical conductivity decreased, and that coarse graphite accentuated this effect. Silicon reduced both conductivities, provided that it did not produce graphitisation, but, if it did, the thermal conductivity increased. Phosphorus produced a slight reduction in both conductivities, and copper a marked reduction, while nickel reduced both conductivities provided there was no increase in the graphite content. The replacement of silicon by nickel in a cast iron raised both the electrical and thermal conductivities. The influence of chromium was not uniform, but in general it increased the electrical conductivity and reduced the thermal conductivity. These results are in accordance with the results previously obtained by the author[7] on the thermal conductivity of plain and alloy cast iron, except that in his determinations chromium was found to increase the thermal conductivity.

5 D. Hattori. *Journal of Iron and Steel Institute*, 1934, Vol. 129, p. 289.
6 E. Söhnchen. *Archw. fur des Eisenhuttenwesen*, 1934, Vol. 8, p. 223.
7 J. W. Donaldson. Proc. Inst. Mech. Eng., 1928, No. 4, p. 953.

Exhibition and Conference on Welding in Swansea

On March 4 last, some 700 people from the works all over South Wales, and an even wider area, congregated at the University College of Swansea, to attend a Conference and Exhibition on Welding, which had been organised by Professor F. Bacon.

The exhibition was held in the Engineering Department of the College, and comprised exhibits by 22 engineering firms and four testing institutions. A local exhibit of special interest illustrated the welding investigations made by the British Mannesmann Tube Co. in association with the "Unit" Superheater and Pipe Co., with a view to taking up the construction of the Loeffler boiler. Another striking local exhibit of pipe-work welding came from the National Oil Refineries, Llandarcy. The fatigue testing of welded joints was seen in progress on the College stand, as also Professor F. Bacon's extensive collection of service and experimental fractures.

The Conference included lantern lectures by Professor F. C. Lea, O.B.E., D.Sc. (Chairman, I.Mech.E. Research Committee on Welding) on "Some Researches in Connection with Welding," by Mr. A. Ramsay Moon, B.A.,M.I.Struct.E. on "Welded Structures"; and by Mr. J. S. Caswell, M.Sc., on "Welding in Strip Mill Practice." There was also an informal discussion on "Topics of Importance to Practical Welders," presided over by Mr. W. C. Mitchell, B.Sc., M.I.Mech.E.

Although Professor Lea's lecture was held in the largest hall of the College, the seating capacity of 500 proved inadequate. Principal C. A. Edwards, D.Sc., F.R.S., occupied the chair. The discussion which followed was opened by Mr. C. H. Davy, Member of the I.Mech.E. Committee on Welding Research, and Chief Research Engineer to Messrs. Babcock and Wilcox. Mr. Ramsay Moon (Murex Processes, Ltd.); Mr. J. A. Dorrat (Metropolitan Vickers Electrical Co., Ltd.); and Mr. L. C. Percival, B.Sc., B.Met. (Technical and Research Department of the British Oxygen Co., Ltd.) also spoke.

The Conquest of the Pamirs

By A Special Correspondent

The mountainous region of the Pamirs in Central Asia is being developed. After a systematic study of this country mineral deposits have been discovered and in some instances their commercial exploitation has commenced. The developments in this region are briefly surveyed in this article.

BEFORE the Russian revolution the Pamir was a country of fantastic legend born of generations of people inhabiting this stern mountainous region, this country of rock and ice, practically unexplored, and indicated on the old geographic maps in considerable parts by white patches. The political history of this country during the last century was strongly affected by the struggle of Tsarist Russia and England for influence in the Middle East. After the revolution and the civil war, an approach was made by the people of the Pamirs, with the help of the Soviet Union, towards the task of reconstruction, and an all-round and systematic study of the productive forces of the Pamirs and the adjoining mountainous region was undertaken.

At great heights, where " only mist and eagles reigned," in mountain gorges, on glaciers, at turbulent rivers, groups of geologists were scattered, and by practical work they have refuted the once-held theory that the Central Asiatic mountain regions were bare of minerals. Many authorities on Central Asia have maintained that in the South, from Syr-Darya, there could not possibly be any metal resources, that Central Asia had once been a sea, which had left deposits and precipitations of several kilometres in thickness and that millions of years would be required for these deposits to be washed away by rivers and rains and destroyed by wind before seams containing metal would be uncovered.

The work of the last few years has completely refuted these theories ; a Central Asiatic gold industry has been created, with great possibilities for its future development and growth. The Pamir " Zolotoye Ozero " (Golden Lake) has been discovered. The position is as favourable in regard to other minerals. During the last few years, the Tajik-Pamir expedition alone has given over to the appropriate trusts a number of deposits for commercial exploitation and detailed prospecting. In several deposits discovered by the expedition, experimental raising of ore is now proceeding. In 1935, during the process of prospecting work, 200 tons of tin ore were raised at the Takfonsk deposits. Prospecting work has been going on all the winter at these deposits. The first tons of tin concentrates were obtained from the deposits in the Turkestan range. From the Marguzorsk antimony deposits, the Lyangarsk wolfram deposits, the Chauvaisk mercury deposits, the Archa-Maidansk arsenic deposits, the first hundreds of tons of ore have been raised.

Special mention must be made about the discovery in 1935 of the first bauxite deposits in Central Asia, which are to be commercially prospected this year. An analysis of the bauxite showed contents of industrial aluminium.

The expedition also discovered a number of deposits of useful non-metallic minerals. The Takobsk deposits of fluor spar are already being exploited for industrial purposes. The working of the deposits of excellent optical fluorite (at the lake of Kuli-Kolon), in appearance resembling pure chemical ice, will free the country from the need to import this mineral, very necessary for the manufacture of different precision instruments. Deposits of Iceland spar have been discovered in the Pamirs in the region of Buz Tere, deposits of mica in the valley of the river Lyadjuar-Darya and along the river Shakhdarya (where mica is already being raised), wonderful stones—rose-coloured spinel, pure Talc, the supplies of which run into several thousands of tons, and different kinds of building materials, have been found which are already being used for local building purposes.

One of the aims of the expedition was to find mineral fuel—coal and peat. Coal has not yet been found, but two deposits of peat have been discovered at Djamantal and Murgaba, where it is proposed to raise 700,000 tons.

With the aim of studying the geographic formation of the Pamirs and the adjoining mountain ranges and for a further investigation of their mineral resources, work was undertaken on the compilation of geographic maps of the Pamirs. These maps will be published in time for the International Geographical Congress to be held in 1937. But many years will still have to pass before these magnificent, stern and inaccessible mountains will yield up their metal so much needed by the country.

The white spots on the maps of the Pamirs are gradually becoming smaller as a result of the persistent efforts of mountaineers, cartographers, geomorphologists, geographers, topographers. A new Pamir has been opened up, with new glacial rivers, new snow-capped mountain ranges.

The Pamir, with its great mountain elevations and vast glaciers is a region of exceptional peculiarities in regard to weather, climate and hydrological regime. A study of these peculiarities is of immense practical and scientific importance. It is necessary not only for our understanding of the atmospheric processes there, but for an estimation of the water resources for the irrigation of vast territories in Uzbekistan and Tajikistan for cotton-growing, as well as for the building of hydro-power stations. The main water artery—the Amu-Darya—is fed by the Pamir glaciers.

All these questions and many others necessitated the establishment of meteorological services in the Pamirs. Existing meteorological data was too uncertain and incomplete. During the last few years much work has been done on the Pamirs in meteorology and hydrology ; a network of meteorological stations was organised in different parts of the region. A great achievement was the establishment of an observatory on the glacier Fedchenko, at an altitude of 4,200 metres. The building of this well-equipped observatory was carried out under the most difficult of natural conditions. It was finished at the end of 1933, since when it has been working continuously.

As part of the general plan for the study of the Pamirs, was the work of the expedition of the Central-Asiatic University, led by Professor P. A. Baranov, on the question of crop-raising in the high mountain valleys. As a result of this work it has been found that crops can be successfully grown in the Pamirs. This is a fact of great political and economic significance ; crop growing in the Pamirs would eliminate the need to transport foodstuffs and would thus provide the necessary conditions for the settlement of the nomads of the Eastern Pamirs.

The experimental sowing of crops was carried out in different regions, and it has been established beyond a doubt that the raising of crops in the Pamirs is an actual possibility. Pamir wheat is one of the most productive and valuable in the world. Its ears are 22–23 centimetres in length and contain over 100 grains. The population of the Pamirs have insufficient vitamins in their food. Vegetables were transported from other parts and in some regions they were quite unknown, the population not even having tasted them. The experiments carried out by the expedition show that it is possible to grow cabbages, beet, carrots, radishes and potatoes, the latter having yielded a crop of 3 to 3·5 kilograms per plant.

The theory that there was no suitable soil in the Pamirs

for agriculture has been disproved by the expedition; an area of 25,000 hectares has been marked, which is quite suitable for arable farming.

A provisional estimation of the fish resources of the Pamir lakes, arrived at on the basis of numerous experimental catches, shows that the entire population of the Pamirs could be supplied with fish from Lake Yashil-Kil alone.

Much fruitful work has been done during the last few years in the study of the high mountainous region of the Pamir Arctic. In their inaccessibility and wildness, these little-known regions are very like the extreme northern territories of the Soviet Union.

Side by side with a comprehensive study of the Pamirs, much work has been done in the reconstruction of the region. The lack of roads has played an enormous part in the backwardness of the Pamirs. Roads were unknown in the country. The only ways of communication were the mountain paths winding above the precipices. Now the whole of the Pamirs is intersected by a good motor road stretching over a length of 740 kilometres. Air communication has also been developed. A careful study has been made of high mountain air routes, and now regular mail and passenger air services have linked up the Pamirs with the different regions of Central Asia.

In places where, until recently, wild animals roamed, settlements have been built, with schools, libraries and electric power stations. These are only some of the great changes that have taken place in the development of the Pamirs.

Brass and Copper Forgings

THE forging of brass and copper is an important phase of the non-ferrous industry, the possibilities of which have not been exploited to the extent to which they deserve. While some little development work has been done, it is the opinion of large producers that there is an opportunity to extend further the applications of these products in the engineering fields. With these general objectives in view, E. F. Cone* deals with the production of brass and copper forgings by one of the largest American producers—The Revere Copper and Brass, Inc.

Brass forgings are superior to brass castings on many points. The production of a forging involves a saving of metals, and if a proper die design is assured, less machining is necessary, and in some cases may be eliminated. There is also greater density, freedom from porosity, sand, blowholes, and other foreign matter, as well as greater strength. The physical properties of forgings, as well as of castings, depend, among other factors, on their microstructure, that of the forging being characterised by a fine, uniform grain. Comparative physical properties average about as follows:

	Sand Castings.	Brass Forgings.	Copper Forgings.
Tensile strength (tons per sq. in.)	9·2	18·4 to 23·0	13·8 to 16·1
Elon. on 2 in.	17·0%	20 to 55%	35 to 50%
Brinell Hardness	60	70 to 82	40 to 50

For copper forgings, the raw material is hot-rolled rounds or squares of virgin metal and, for the forging of brass extruded rods of various dimensions and shapes, generally round or square. Sharp edges on forgings are not desirable from a production point of view, and should therefore be avoided. Lead is introduced into standard 60–40 brass up to a maximum of 0·5%, to increase its machining properties.

Forging equipment consists of crank, knuckle, or screw presses of 150 to 450 tons each, and board or steam hammers rated at 400 to 2,500 lb. each. Each press or hammer has close to it a heating furnace, pyrometrically controlled, and having a neutral atmosphere, in which the metal to be forged is preheated. The dies are a vital part of the equipment, whether in presses or hammers. Press dies are usually made of either of two types of chrome-vanadium-tungsten steel, and have to be properly hardened after cutting the impression, while hammer dies are made of chrome-nickel-molybdenum steel, and are used without further heat-treatment after the die has been cut. In general, a longer life is obtained with hammer dies than with press dies.

The extruded forging rod which comes from the extruder free from scale and with a clean surface, which renders pickling unnecessary, is cut into slugs to suit the forging required. These are then heated in the preheating furnaces, usually at 760 to 770° C., and then forged in the press or under the hammer, depending on the character and design of the product. When pressed forgings are made only one is produced at a time, except when the parts are small, but when the hammer is used it is customary to make from two to eight forgings in multiple dies at the one time. In general, one stroke in a press produces a forging, whereas three to eight or more blows are necessary under the hammer. In determining whether a given forging should be made under the press or under the hammer, many factors have to be considered, the press being generally favoured for forgings which involve a small draft, while in forgings, where a heavy draft of the order of 5° is required, the hammer is preferred. At the same time, there is a wide range of forgings which can be economically produced, either by the press or by the hammer, and general conditions in the operating shop usually determine the selection of the type of equipment to be used in such cases. Commercial forgings are produced in finished weights, ranging from an ounce up to 10 lb.

It is not the usual practice to heat-treat the finished forgings, although in special cases a moderate annealing treatment of 30 mins. at 315° C. to 425° C., followed by air cooling, is found to relieve stresses. Final preparation of the forgings is also varied in particular cases. Some are subjected to pickling before plating or otherwise, while others are tumbled to improve their appearance.

Consideration is also given to the extent to which variations in structure of extruded brass rods affect the forging qualities of the metal, and it is suggested that there is no connection between the structure of the extruded rods and the forging properties, as the extruded metal when forged is heated into a plastic range, where working stresses are fully relieved. It is also further suggested that, where cracking and hot shortness are encountered in forging, such cracking results from non-metallic inclusions, gas or contraction cavities, or other casting imperfections, and not from the variation in structure of the extruded rod.

* E. F. Cone—Metals and Alloys, 1935, Vol. 6, pp. 337-341

The Technical Literature Series of the Copper Development Association has been further augmented by a recent publication on Copper for Architecture in Sweden and Denmark. The book consists of extracts from a memorandum to a committee, compiled by two members of the staff of the Copper Development Association, London, and illustrated by their own drawings and snapshots, following a short visit to Denmark and Sweden to investigate the architectural use of copper in those countries. It is noteworthy that copper is used very extensively on buildings in Sweden and Denmark, especially those of any size or permanence, in spite of the price. This book will be of particular interest to architects and building engineers; it is a worthy production, the illustrations especially being excellent. Those desiring. copies should write to the Copper Development Association, Thames House, Millbank, London, S.W.1.

Recent Developments in Materials, Tools and Equipment

New Plant for the Manufacture of Die-blocks

DURING recent years there has been considerable development in the application of drop forgings or stampings, and the demand for reliable die-blocks has increased, with the result that much attention is being directed to their manufacture. Some firms concentrate on large die-blocks, others are equipped more especially to meet requirements for smaller sizes, few firms, however, cover the range the between two extremes. It is generally known, for instance, that the firm of Thos. Firth and John Brown, Ltd., is equipped for manufacturing die-blocks of all sizes, and is indeed one of the few firms in the country able to tackle the largest blocks at present in use, which weigh seven or eight tons apiece. In view of the increased demand this firm's facilities have recently been considerably extended by putting into production a new plant designed exlusively for the rapid production of the small and medium sizes forged steel die-blocks ranging in weight from ½ cwt. to 15 or 20 cwt.

This new plant comprises a 5-ton steam hammer, a modern gas-fired reheating furnace, a normalising and hardening furnace, a tempering furnace, an oil-quenching tank and the necessary auxiliary equipment, together with a complete range of tools for the manufacture of both parallel-sided and tapered die-blocks. The furnaces are all of the gas-fired type of most recent design, thus ensuring uniform heating and uniform hardness of the finished block. The whole furnace plant is fitted with autographic pyrometric control to ensure accuracy of heat-treatment; and an inspection and Brinelling section completes the equipment. Die-blocks required to be machined all over are machined in the extensive machine shops attached to the forge department of the works.

Showing the 5-ton hammer in Firth-Brown's new die-block plant.

speaking a slightly lower maximum hardness is to be preferred.

Atlas "*A*" is a steel used for dies intended for stamping carbon steels. It should not, however, be used for dies having very deep impression, or for very heavy stamping dies, but is a good wearing material for ordinary work.

Atlas "*B*" is a steel of similar hardness, but increased toughness, brought about by lowering the carbon content and substituting an oil-quenching treatment for normalising.

B. 21 *and B.* 23 are two steels containing 1¼% of nickel, and possessing increased hardness, which give excellent service when working tough alloy steels. The choice between them will depend upon the exact nature of the block and the impression which is to be sunk in it.

RANGE OF STEELS FOR DIE-BLOCKS.

Ref. No.	Trade Name.	Corresponding Standard Spec.	Treatment.	Brinell Hardness.	Essential Analysis.			
					Carbon. %	Nickel. %	Chromium. %	Molybdenum %
A. 6	Atlas "A"	B.S.I. 224. No. 1	Normalised	196/255	0·60	—	—	—
A. 5	Atlas "B"	None	Oil-hardened and Tempered.	196/255	0·45	—	—	—
B. 21	Atlas "ND"	B.S.I. 224. No. 2	Normalised	196/255	0·60	1·25	—	—
B. 23	Atlas "NCD"	B.S.I. 224. No. 3	Normalised Oil-hardened and Tempered	229 max. 285 max.	0·55	1·25	0·65	—
B. 24	Atlas "3NCD"	B.S.I. 224. No. 4	Oil-hardened and Tempered	241/285	0·35	3·30	0·80	—
B. 27	Atlas "C"	None	Oil-hardened and Tempered	321/364	—	about 1·5	about 0·75	about 0·25

The plant is laid out for rapid and continuous production, and is balanced to maintain a steady output of two tons per shift. Taking into account the time required for heating the forged block to the normalising temperature, soaking at that temperature and cooling again, carbon or alloy-steel blocks supplied in the normalised condition can be delivered four or five days after receipt of the order. Oil-hardened and tempered die-blocks, however, take slightly longer because an extra furnace operation is involved; even so, they are completed within six or seven days.

Qualities of Steel Available

The output of the plant includes die-blocks ranging in hardness from the 196 (4·3mm.) Brinell of Atlas "A" steel (0·55 to 0·65% carbon) to the 364 (3·2 mm.) Brinell of Atlas "C" steel, a special nickel-chromium-molybdenum oil-hardening quality used for the most arduous duty. A Brinell hardness of 364 is the greatest hardness which permits the die-sinking operation to be carried out, using even the best high-speed steel tools available, and generally

B. 24 is a steel of similar hardness to B. 23, but possessing increased toughness, due to the combination of low carbon and high alloy content. It is recommended for die-blocks which, owing to the complicated nature of the impression, might otherwise be weak.

Finally, *Atlas* "*C*" is a steel specially developed to attain maximum hardness combined with a high degree of toughness. It is recommended for die-blocks submitted to severe stresses when stamping hard alloy steels.

New Soviet Alloy

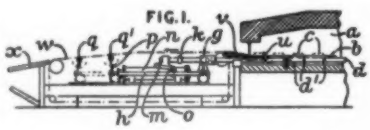
A Soviet engineer named Hershorn, of the Institute of Research in Metals, has developed what is claimed to be a new alloy of iron with an admixture of molybdenum and copper. The qualities of the new alloy are said to be great strength, ductility, and resistance to corrosion. The new alloy is stated to be useful for the construction of boilers, ships, etc.

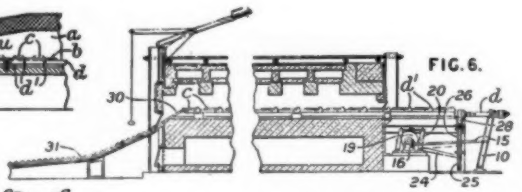
Some Recent Inventions

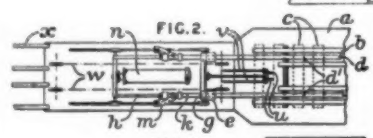
The date given at the end of an abridgment is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.

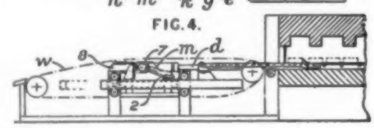
Conveying Furnace Charges

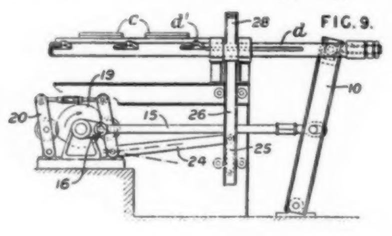
A step-by-step conveyer for articles such as metal bars, billets, plates, trays, etc., comprises a track for supporting such articles, a shaft with projecting fingers, extending longitudinally of the track, means for turning the shaft to bring the fingers into engagement with individual articles, and means for propelling the shaft longitudinally for sliding the articles along the track, the said means subsequently effecting disengagement of the fingers from the articles and return of the shaft to its initial position. Figs. 1, 2 show an arrangement for feeding plates c from a furnace a on to a ramp v and conveyer w leading to a feed table x of a rolling mill or like machine. The plates c are fed through the furnace a on tracks b by fingers d^1 on shafts d propelled longitudinally by a carriage h which is operated by a motor n having its piston head connected to the front of the carriage. When the motor is operated, rollers o on the carriage engage cams m on the shafts d and rotate these shafts so as to bring the fingers d^1 into a vertical position behind a plate. A bracket g on the carriage, moving idly along the shafts d, simultaneously engages collars k and propels the shafts longitudinally. At the end of this movement, a bracket p on the carriage trips a valve q to effect the return movement. During the initial period of this movement, the rollers o positively rotate the cams m or permit them to return by gravity so that the fingers d^1 are moved to a position enabling them to pass under the plates c. The collars g then engage collars e to return the shafts longitudinally, a trip valve q^1 being provided, if desired, for automatically cutting off the power. Gravity pawls u engage behind the leading plate c on the completion of the return stroke and, on the next feeding stroke, propel the plate along the ramp v to the conveyer w. In a modification, Fig. 4, in which the plates are fed directly to the conveyer w, the cams m consist of helical blades on extensions of the shafts d engaging between pairs of rollers 2 on the carriage, the latter comprising wheels 7 running on tracks 8. In another modification, Figs. 6, 9, in which plates c are delivered from the furnace to a shoot 30 leading to a conveyer 31, the shafts d are controlled by a motor-driven crank 16. With the parts as shown in Fig. 9, on clockwise rotation of the crank, lost-motion between a rod 15 and lever 10 is taken up, and a cam 19 simultaneously rocks arms 20 to the position Fig. 6 and, through a lever 24 and arms 25, lowers racks 26 which, by engagement with toothed sectors 28 on the shafts d, turn the fingers d^1 to their upturned position behind an article c. During the remainder of its forward throw, the crank rocks the lever 10 from right to left to convey an article one step. On the return throw the fingers d^1 are restored to their down-turned position and the shafts d returned longitudinally. Each finger-shaft may be provided with two sets of fingers so disposed that, on one stroke, one set of fingers propels objects along an upper track in one direction and, on the reverse stroke, the other set propels objects reversely along a lower track. According to the first Provisional Specification, a vertical sliding door may be fitted over the delivery doorway of the furnace a, Fig. 1, and may be raised automatically through linkage at the moment when the leading plate c is to be moved through the doorway by the pawls u.



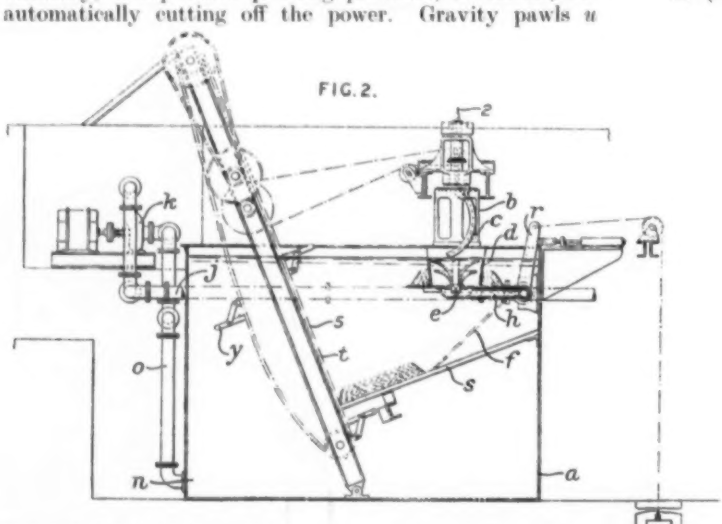








438,743. W. R. Marchant, 87, Sunnybank Road, Pontypool, Monmouthshire, and Baldwins, Ltd., Great Trinity Lane, Garlick Hill, London. [Class 51 (ii)].



Heat Treating and Coiling Steel Rods

Medium or low carbon steel rod is chilled by feeding the rod in a hot condition from a rolling-mill to a coiling device—*e.g.*, a perforated drum, to the cente of which water is fed and caused to flow outwards radially while it is being coiled. The rod 2 from the rolling mill is passed through a tube c mounted on a rotating coiling frame v and is coiled round a fixed perforated drum d suspended by a ball bearing from the frame. A squared projection e on the lower end of the drum d fits into a square opening on a plate f which is supported by a pipe h pivotally mounted on the tank a containing the quenching liquid and counterbalanced by a suitable weight q suspended from a chain connected to a lever r. The pipe h is connected by a pipe j to a centrifugal pump k which draws water from the tank through an opening n and a pipe o, water then being forced inside the coiling drum d and radially outwards through the perforations in the drum. When the rod has been cooled on the drum d the pipe h and the plate f are swung downwards and the coil slides down the bars s until arrested by abutments 5, the plate f, etc., returning to the horizontal position. The coils are removed from the abutments 5 by arms y on an endless conveyer t and conveyed out of the liquid in the tank a.

438,421. H. D. Lloyd, The Old Vicarage, Stretton, Warrington. (Class 72).

Business Notes and News

Pictorial Account of the Development of Science and Industry

Exhibited in the Library of the North East Coast Institution of Engineers and Shipbuilders are a number of photographs illustrating developments in science and industry during the past quarter of a century. By the courtesy of The Science Museum, South Kensington, where these photographs were recently exhibited, they have been lent to the Institution.

Owing to limitation of space, the "exhibitions" will be changed fortnightly until all photographs have been shown. Those now on show deal with Aeronautics and the Structure of Matter, while the subjects of the remaining exhibitions are Ships and Marine Engineering; Land Transport, and Power Production and Transmission; Pumps and Fire Protection, and Machine Tools, and Electric Power and Communication.

The pictures showing the Structure of Matter begin with diagrams giving a general idea of the Rutherford-Bohr Nuclear Atom; they include also actual photographs showing the splitting up of atoms and the wave nature of X-rays and of electrons. Under Aeronautics, the photographs begin with the Short biplane of 1910, and end with one showing the air liner *Scylla* of 1935.

Members of the public will, upon application to the Secretary of the Institution, be allowed an opportunity of seeing this interesting pictorial account of the development of science and industry.

Vickers Dividends

We are advised that the Directors of Vickers, Ltd., will recommend the following dividends for approval at the 69th Annual General Meeting to be held on April 3, 1936:—

A dividend for the year 1935 at the rate of 8%, less income tax at 4s. 6d. in the £ on the ordinary shares of the Company, payable on Friday April 3, 1936.

The capitalisation of the sum of £2,052,580 13s. 4d. from the Company's reserves by applying that sum in paying up in full 12,315,484 unissued ordinary shares of 3s. 4d. and distributing those shares as fully paid bonus shares amongst the ordinary shareholders as on April 3, 1936, being in the proportion of one bonus ordinary share of 3s. 4d. in respect of every ordinary share of 6s. 8d. held.

The consolidation of the above 12,315,484 ordinary shares of 3s. 4d. each and the existing 12,315,484 ordinary shares of 6s. 8d. each into 12,315,484 fully paid ordinary shares of 10s. each with a view to their being converted at an extraordinary meeting to be held on April 15 into £6,157,742 ordinary stock, to be transferable in units of 10s.

The conversion into stock of the Company's issued and fully paid 5% preference and 5% (tax free) cumulative preference shares of £1 each to be transferable in units of £1.

Copper Production in Canada

Finally revised statistics relative to the production of new copper in Canada during the calendar year 1934 reveal a total of 364,761,062 lb., valued at $26,671,438, as compared with 299,982,448 lb. ($21,634,853) in 1933. The increase in production continued throughout 1935, output during the first nine months having risen from 266,302,345 lb. in 1934 to 312,520,346 lb. in 1935. Production in 1934 constituted an all-time high record for the industry, the previous highest total being that reported in 1930, amounting to 303,478,356 lb.

During the year copper was produced in Quebec, Ontario, Manitoba, Saskatchewan and British Columbia. The first two provinces were the Dominion's greatest producers, contributing 20·3% and 56·2% respectively, of the total output of 364,761,062 lb. The recorded output for the year included 334,703,227 lb. contained in blister and anode copper, 16,674,356 lb. in ores, concentrates and copper matte exported, and 13,383,479 lb. in exports of nickel-copper matte.

The United Kingdom is now Canada's principal market for copper, and the pronounced change in the upward flow of Canadian copper since the Ottawa Agreements is emphasized, by the fact that in 1930 the United States took 95·7% of Canada's copper exports, whilst only 1·9% was shipped to the United Kingdom; in 1934 the percentage exported to the United States had fallen to 13·1%, whilst the value of consignments to the United Kingdom had increased to 64·2%.

New Industry for Wolverhampton

It is announced that the Fischer Bearing Co., have acquired a large portion of the Moorfield Works, Wolverhampton. This Company is an offshoot of the important German firm of Kugelfischer, of Schweinfurt, which was established in 1883, and employs approximately 12,000 workpeople in the manufacture of steel balls and bearings. The area of the factory premises, which have been acquired from the owner, Mr. F. H. Farrar, of the Villiers Engineering Co., is 19,342 square yards—approximately one-third of the Moorfield works.

It is expected that the work of equipping the factory for the manufacture of all types of precision steel balls and bearings will begin almost immediately.

Nickel Coins

The first nickel coin was struck 55 years ago, and now no fewer than 27 countries have issued pure nickel coins. The most recent pure nickel coins to be put into circulation are the ten- and five-gulden pieces of the free state of Danzig. This follows the successful use of the one- and half-gulden pieces which were struck in 1932. The list includes most of the important industrial countries except England and the U.S.A. The English silver coins, however, contain 5% of nickel, while the American "nickel" is actually made of a 75·25 copper nickel alloy, a widely used coinage material for lower denominations.

The most recent pure nickel coins.

British Foundry School

The British Foundry School, which offers a training of one year's duration of the most advanced character, in foundry science and practice, made an excellent beginning in October last and thirteen students are taking the course for the first session, now in its second term. In addition to the lectures and laboratory work, supervised by a permanent lecturer-in-charge, Mr. J. Bamford, B.Sc., special courses are given by members of the staff of the Birmingham Central Technical College in which the School is housed. Furthermore, over fifty lectures were given during the first term by nationally-known specialists in various aspects of foundry work, and similar numbers are arranged for the second and third terms. Each week a foundry visit is made, and during the session it is hoped to arrange for a three-day visit to another foundry centre, during the last term.

Students in the main have been nominated by their employers, and the School authorities are now prepared to receive the names of prospective students for next session, beginning in September, 1936. They will be required to have reached a suitable standard of preliminary education and to have had adequate practical experience in foundry work, ferrous (iron, steel or malleable), or non-ferrous. The fee for the course is £30 and students who pass the qualifying test at the end of the course receive a diploma endorsed by the Board of Education.

The School is supported by the leading institutions and associations in the industry and by manufacturing firms who nominate representatives to the Governing Body. A prospectus and further information may be obtained from the Secretary of the School, Central Technical College, Suffolk Street, Birmingham, or from the Honorary Adviser to the School, Mr. J. G. Pearce, 21, St. Paul's Square, Birmingham, 3.

Canada's Imports of Iron and Steel, 1935

Canada's imports last year of iron and its products totalled $112,136,244, as compared with $93,615,090 in 1934.

Imports from the United Kingdom rose from $18,683,975 to $20,407,113; whilst imports from the United States also increased from $71,056,276 to $86,473,621.

MARKET PRICES

ALUMINIUM.

98/99% Purity		£100	0	0

ANTIMONY.

English		£73	0	0
Chinese		62	0	0
Crude		31	0	0

BRASS.

Solid Drawn Tubes	lb.	9¼d.
Brazed Tubes	„	11¾d.
Rods Drawn	„	8½d.
Wire	„	7¾d.
*Extruded Brass Bars	„	4¼d.

COPPER.

Standard Cash		£36	2	6
Electrolytic		40	5	0
Best Selected		39	10	0
Tough		39	0	0
Sheets		68	0	0
Wire Bars		40	15	0
Ingot Bars		40	15	0
Solid Drawn Tubes	lb.	10¼d.		
Brazed Tubes	„	10½d.		

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	3	3
‡Ferro Tungsten	„	0	3	0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL: 2–4% Carbon, scale 11/- per unit	ton	29	15	0
NOMINAL: 4–6% Carbon, scale 7/- per unit	„	22	7	6
NOMINAL: 6–8% Carbon, scale 7/- per unit	„	21	12	0
NOMINAL: 8–10% Carbon, scale 7/- per unit	„	21	12	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	33	10	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	5	0
§Guar. max. 0·7% Carbon, scale 12/6 per unit	„	37	5	0
‡Manganese Metal 97-98% Mn.	lb.	0	1	2
‡Metallic Chromium	„	0	2	5
§ Ferro-Vanadium 25–50%	„	0	12	8
§ Spiegel, 18–20%	ton	7	10	0
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	8	17	6
45/50% basis 45%, scale 5/- per unit	„	12	5	0
70/80% basis 75%, scale 7/- per unit	„	17	17	6
90/95% basis 90%, scale 10/- per unit	„	28	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	12	17	6
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4¼
Ferro Phosphorus, 20–25%	ton	20	0	0
§ Ferro-Molybdenum, Molyte	lb.	0	4	6
§ Calcium Molybdate	„	0	4	2

FUELS.

Foundry Coke—				
S. Wales	—	1	6	6
Scotland	—	1	10	0
Durham	1 1 6 to	1	3	0
Furnace Coke—				
Scotland	—	1	5	0
S. Wales	—	1	0	6
Durham	—	0	19	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)		£60	10	0
*Commercial Ingots		44	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0	9
*Cored Bars	„	0	0	11

LEAD.

Soft Foreign	£16	13	0
English	18	15	0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	10	10	0
Best Bars	10	2	6
Common Bars	9	5	0
Lancashire—			
Crown Bars	9	12	6
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars	9	12	6
Marked Bars	12	0	0
Unmarked Bars from	7	5	0
Nut and Bolt Bars £7 10 0 to	8	0	0
Gas Strip	10	12	6
S. Yorks—			
Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	11d.
†Sheet to 10 W.G.	„	11½d.
†Wire	„	1/0¼
†Rods	„	11½d.
†Tubes	„	1/1¾
†Castings	„	1/-

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	13	6
Foundry No. 1	3	16	6
„ No. 3	3	13	0
N.E. Coast—			
Hematite No. 1	3	11	0
Foundry No. 1	3	12	6
„ No. 3	3	10	0
„ No. 4	3	9	0
Silicon Iron	3	10	0
Forge	3	9	0
Midlands—			
N. Staffs Forge No. 4	3	11	0
„ Foundry No. 3	3	15	0
Northants—			
Foundry No. 1	3	15	6
Forge No. 4	3	8	6
Foundry No. 3	3	12	6
Derbyshire Forge	3	11	0
„ Foundry No. 1	3	18	0
„ Foundry No. 3	3	15	0
West Coast Hematite	4	6	0
East „	3	11	0

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron Kr. 106
Billets Kr. 240-310 £12 7 6–£16 0 0
Wire Rods Kr. 290-340 £15 0 0–£17 10 0
Rolled Bars (dead soft) Kr. 200-220 £10 6 0–£11 7 0
Rolled Charcoal Iron Bars Kr. 290 15 0 0
All per English ton. f.o.b. Gothenburg.
Converted at £1 = Kr. 19.40 approx.

SCRAP METAL.

Copper Clean	£29	0	0
„ Braziery	27	0	0
„ Wire	—		
Brass	19	10	0
Gun Metal	27	0	0
Zinc	8	0	0
Aluminium Cuttings	74	0	0
Lead	13	10	0
Heavy Steel—			
S. Wales	2	5	0
Scotland	2	17	6
Cleveland	2	17	6
Cast Iron—			
Midlands	2	10	0
S. Wales	2	17	6
Cleveland	3	2	6
Steel Turnings—			
Cleveland	2	0	0
Midlands	2	2	0
Cast Iron Borings—			
Cleveland	1	7	6
Scotland	1	17	6

SPELTER.

G.O.B. Official	—		
Hard	£12	10	0
English	17	2	0
India	13	15	0
Re-melted	14	0	0

STEEL.

Ship, Bridge, and Tank Plates			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	8	10	0
„ „ (Marine) „	—		
„ „ (Land), N.E. Coast	8	10	0
„ „ (Marine) „	8	17	6
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	10	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £6 17 6 to	7	2	6
Medium Basic £6 12 6 and	7	0	0
Soft Basic	5	10	0
Hoops £9 10 0 to	9	15	0
Manchester			
Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to 3/16 in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£214	0	0
English	214	0	0
Australian	214	0	0
Eastern	219	10	0
Tin Plates I.C. 20 × 14 box	18/9		

ZINC.

English Sheets	£24	5	0
Rods	26	5	0
Battery Plates	—		
Boiler Plates	—		

*McKechnie Brothers, Ltd. March 12 † C. Clifford & Son, Ltd., March 12 ‡ Murex Limited, March 12

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, March 12